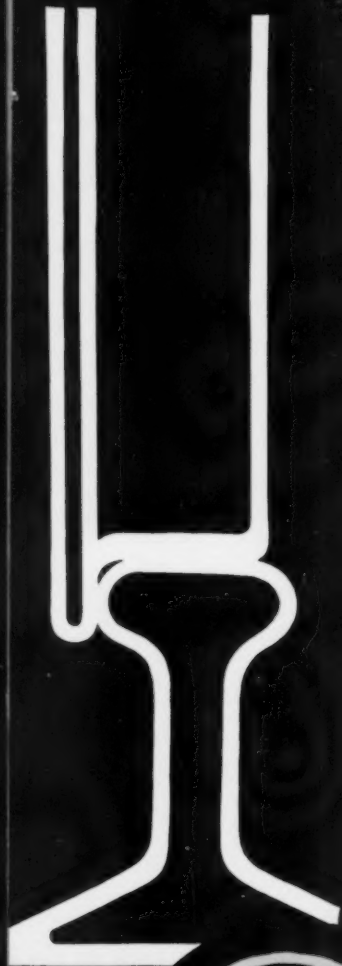


METAL PROGRESS



METAL PROGRESS

1-8-16
OR MORE!

Surface CONTROLLED ATMOSPHERE...
PIT-TYPE FURNACES
... in Modern Production Plants



A battery of 16 (12 shown) Pit-Type Furnaces used for carburizing roller bearing parts.



A battery of 8 Pit-Type Furnaces used for carburizing cam shafts in an automotive plant.



More complete details are given in this new Bulletin SC-149. Write for your copy today!

Can be used for...

- ★ GAS CARBURIZING
- ★ HOMOGENEOUS CARBURIZING
- ★ DRY (GAS) CYANIDING
- ★ CLEAN HARDENING
- ★ BRIGHT ANNEALING

These Features make them
OUTSTANDING:

- ✓ **EXTERNAL OR INTEGRALLY-BUILT RX ATMOSPHERE GENERATOR** • Pit-Type furnaces are used with the various 'Surface' atmosphere generators. For example, an RX furnace, or one or more furnaces may be manifolded to a 'Surface' RX, DX, or NX Atmosphere Generator.
- ✓ **BASKET OR FIXTURE LOADING** • Small parts can be mass-loaded in a basket and lowered into position in the pit-type furnace. Long, irregular parts may be suspended from a fixture for minimum distortion to parts during heat treatment.
- ✓ **RADIANT TUBE HEATING** • With the 'Surface' Radiant Tube heating principle, no muffle is required—there's no contamination of the furnace atmosphere with products of combustion—no muffle replacement—economy in operation. 'Surface' Pit-Type Furnaces are built in effective pit sizes up to 4 ft. wide by 8 ft. deep, and larger.

RX, NX AND DX ARE TRADE MARKS OF SURFACE COMBUSTION CORPORATION

Surface Pit-Type Furnaces are adaptable to special runs of a diversity of materials and heat treatments. Especially fitted to areas where floor space is limited and size and shape of parts are unusual.

The outstanding performance of the many 'Surface' Pit-Type Controlled-Atmosphere Furnace installations is your assurance of consistent satisfaction.

SURFACE COMBUSTION CORPORATION • TOLEDO 1, OHIO

Stein & Roubaix, Paris

FOREIGN AFFILIATES:

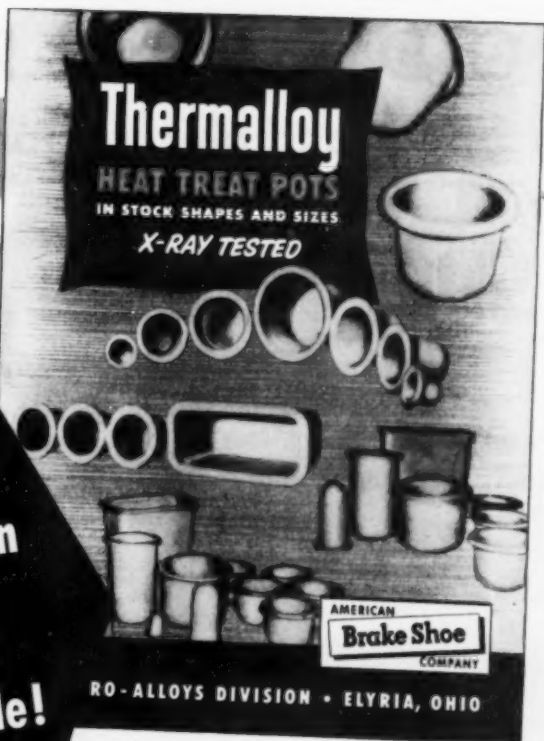
British Furnaces, Ltd., Chesterfield

'Surface'

INDUSTRIAL FURNACES

FOR: Gas Carburizing and Carbon Restoration (Skin Recovery), Homogeneous Carburization, Clean and Bright Atmosphere Hardening, Bright Gas Normalizing and Annealing, Dry (Gas) Cyaniding, Bright Super-Fast Gas Quenching, Atmosphere Malleablizing and Atmosphere Forging, Gas Atmosphere Generators.

**Lists more than
100
Shapes and
Sizes Available!**



Here's help in ordering **HEAT TREAT POTS!**

You can save time and pattern costs by ordering Thermalloy Heat Treat Pots in shapes and sizes available for production. This new bulletin lists 118 pattern numbers available—including both round and rectangular pots.

All Electro-Alloys heat treat pots are x-rayed and pressure tested, to insure the soundness necessary for low cost service. Analyses available for cyanide salt and lead service—and for neutral salt service.

Write for Bulletin T-205. Electro-Alloys Division, Dept. 2091, Elyria, Ohio.

AMERICAN

Brake Shoe

COMPANY

*Reg. U. S. Trade Mark

ELECTRO-ALLOYS DIVISION
ELYRIA, OHIO

MODERNIZE

your Spectrographic Laboratory
with an

NSL

SPEC-POWER



New methods and new applications, most vital to the needs of our country, require the latest in excitation units for your Spectrographic Laboratory. This NSL Spec-Power features: Newly designed air interrupter which allows operator to adjust characteristics of discharge with extreme precision during operation; 30 ampere DC arc and spark ignited AC arc; 5 KVA AC spark providing increased stability and precision; redesigned cabinet for compactness in work area. NSL are suppliers of spectrographic equipment and accessories of all types, including custom-built units designed for your specific work.

Facilities have been enlarged at the National Spectrographic Laboratories in preparation for defense work. Complete analytical service (both control and research) is offered with equipment and personnel available to analyze any type material or any size job. Get your production line into operation fast by using this low-cost service. Perhaps our consultants can be of assistance in solving a laboratory problem for you—we would welcome your inquiries.

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BOOTH NO. 534

**WESTERN
METAL
SHOW**

OAKLAND, CALIF.

Mar. 19-23, 1951

NATIONAL SPECTROGRAPHIC LABORATORIES, INC.

6300 EUCLID AVENUE

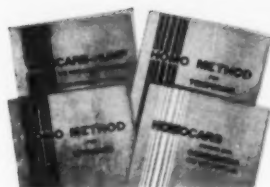
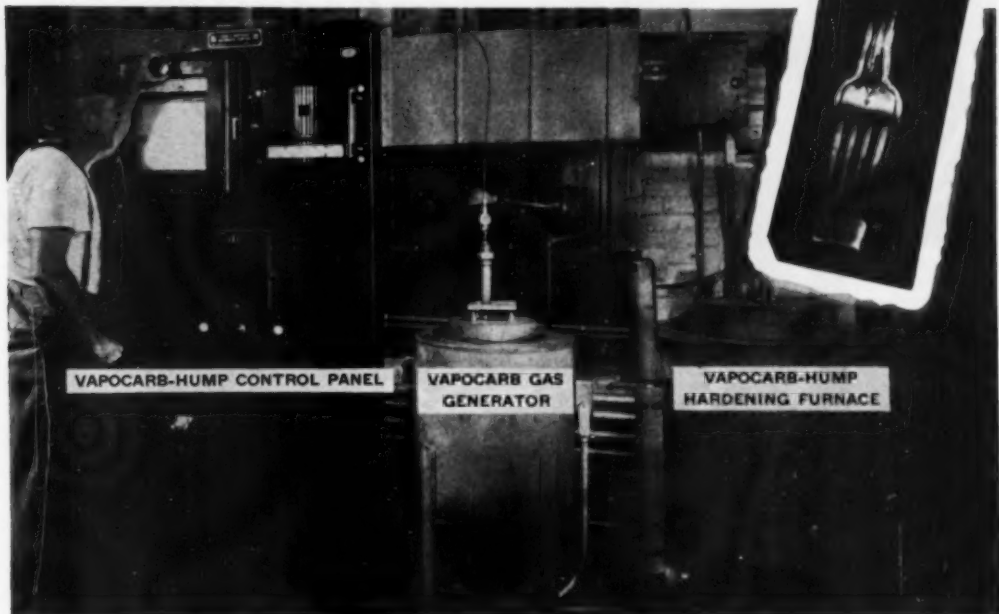
Phone: UTah 1-4664

CLEVELAND 3, OHIO

Metal Progress; Page 298

Silversmith's Way of Improving Tools Gives More Production Per Tool Dollar

Photos courtesy Towle Manufacturing Co., makers of sterling silver knives, forks, spoons and other tableware. Fork die shown is the King Richard Pattern.



Read About COST-CUTTING PROCESSES In These Catalogs

We supply complete Furnace Processes to regulate all action inside the heat-treating furnace, for hardening, tempering, normalizing, carburizing, nitriding, steam-treatment, dry cyaniding. See us if you want heavy production at low cost!

Address nearest office, or 4927 Stenton Ave., Phila. 44, Pa.

Jrl. Ad T-620 (32)

TOWLE Manufacturing Company is one of the firms which successfully lengthens the production life of its forging dies. And Towle's method is basically "right" for other metal-working firms, whether they use expensive tools or simple ones, because Towle is interested in heavy production . . . the last possible piece from every die.

Towle's plan starts with the usual printed form for each die, on which are entered the heat-treating temperature, time, quench, hardness, etc., and the production from the tool, so that when it is retired the company can tell whether or not it produced well.

So far, of course, many plants use this routine; but Towle adds a "pay-off" step—they never throw a sheet away, regardless of the yield from its die. The sheet becomes a guide as to whether succeeding tools should be used

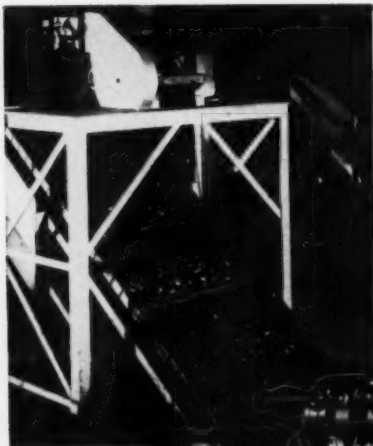
differently, or made of a different steel, or heat-treated differently.

As far as heat-treatment is concerned, the pay-off lies in Towle's facilities for either reproducing or changing the treatment, as they wish. Their Vapocarb-Hump Hardening and Homo Tempering equipments do exactly as the heat-treater says. With them, he can secure the desired structure, hardness and temper, just as a toolmaker can set the feed and speed of a filing machine. Guesswork is ended; the heat-treat becomes a place where specifications are followed to the letter.

Reasons for the dependability of these L&N Methods are given in the Catalogs at left; they explain why more and more plants are finding that it pays to Vapocarb-Hump Harden and Homo Temper all tools.



March, 1951; Page 299



UNIFORM IN QUALITY

*Because Uniformly
Quenched!*

*B & G Series "SC" Self
Contained Oil Cooler.*

Correct oil quenching of heat-treated metals is a fine art which pays dividends in the *uniform quality* of the finished product. Quenching in an oil bath controlled by a B & G *Hydro-Flo* Oil Cooling System eliminates human error . . . reduces the process to a purely automatic operation, in which the final result can be calculated with mathematical certainty.

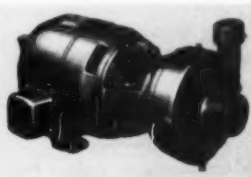
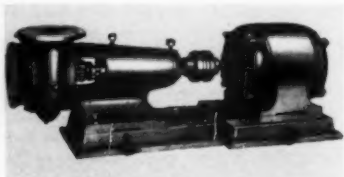
The B & G *Hydro-Flo* Oil Cooler circulates oil at high velocity and with strong agitation through the quench

tank. It pumps heated oil from the tank, cools it and pumps it back again, so that oil temperature is held at the desired degree all through the quench period. Thus every batch of metal is quenched under *identical conditions* and every batch emerges from the quench *identical in quality*.

The B & G Engineering Department is always ready to help with your own quenching problems. Write today.



B & G Quench Tanks
Properly designed to induce maximum turbulence in the quench oil. B & G quench tanks are available in standard models or can be built to meet any specific quenching requirements.



Send for catalogs on complete line of B & G Centrifugal Pumps.




***Hydro-Flo* OIL QUENCHING SYSTEMS**

BELL & GOSSETT COMPANY
DEPT. BY16, MORTON GROVE, ILLINOIS

Heat-treating equipment
since 1916

*Reg. U. S. Pat. Off.



Pittsburgh Steel

announces new facilities for

Oil Tempered Wire

to better serve its customers

Now, **Oil Tempered Wire** has been added to the extensive line of manufacturers wire which Pittsburgh Steel Company has been serving to industry for nearly half a century. The same high Pittsburgh quality that stems from rigid control of its own raw material and long experience in steel production prevails in this new **Oil Tempered Spring Wire**.

Pittsburgh **Oil Tempered Wire** is available in a complete size range, either flat or round, in coils or straightened and cut lengths. Also, Pittsburgh hard drawn **MB** spring wire will be available in a complete range of sizes.

For **Oil Tempered Wire** and **Hard Drawn MB Spring Wire** that is uniform in size, finish, mechanical and metallurgical properties, specify **Pittsburgh**. Write now for information to Department **IA**, Pittsburgh Steel Company, Pittsburgh 30, Pa.



Pittsburgh Wire

A product of Pittsburgh Steel Company

ZIRCONIUM METAL

in the form of

Sponge and Briquettes

with the following analysis

Zirconium	98.8	to 99.6%
	(by difference)	
Oxygen	0.1	to 0.2%
	(estimated)	
Nitrogen . . . . .	.02	to .10%
Iron . . . . .	.2	to .8%
Chromium . . . . .	.02	to .10%
Nickel . . . . .	.01	to .02%
Silicon . . . . .	.02	to .10%

Write our New York Office for detailed information: 3½" diameter briquettes are furnished from ½" to 3" in height with bulk density of 160 to 190 lbs. per cu. ft. The sponge will be ¾" and down with a maximum of 15% through a 10 mesh screen.



TITANIUM ALLOY MFG. DIVISION
NATIONAL LEAD COMPANY

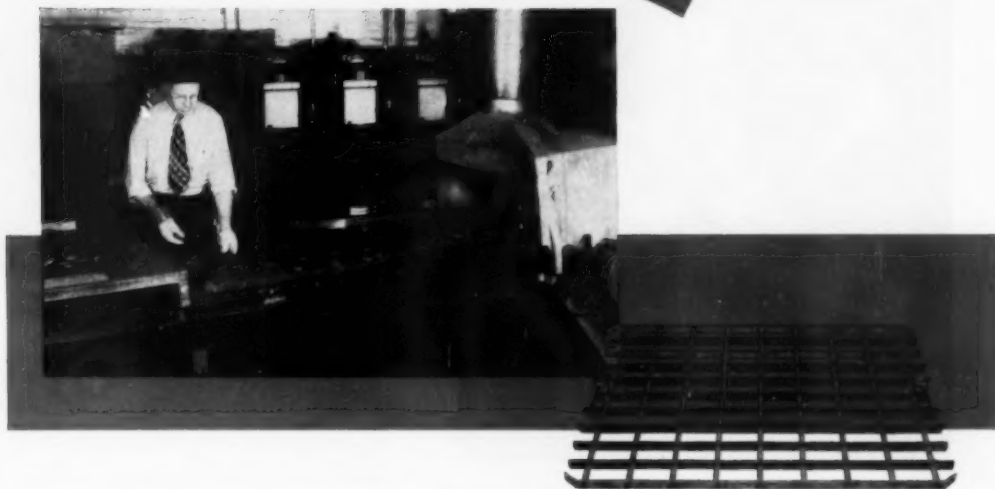
Executive and Sales Office: 111 BROADWAY, NEW YORK CITY • General Offices, Works, and Research Laboratories: NIAGARA FALLS, N. Y.

ROLOCK

FABRICATED

ALLOYS

HEAT AND CORROSION
RESISTANCE



ARTICULATED TRAYS for highest resistance

to WARPING... UNDER EXTREME TEMPERATURES

The photograph above shows an installation of furnace trays built by Rolock for National Stamping Company, Detroit, Michigan. They are used in a General Electric roller hearth furnace operating at 2050 degrees on copper brazing and at 1600 to 1800 degrees on bright annealing.

Flat bar construction of the 60 lb. tray with bent outer bars, to avoid catching on roll guides, gives optimum performance with loads 100 lbs. and over. Hot rolled

bars prevent scoring of furnace rolls... flexible construction eliminates warping and cracking. Handles at ends also serve to index cover screen for small parts. The carefully checked performance proves the importance of job-engineered design for a specific condition.

If you are experiencing tray troubles... short service life, cracking, warping... ask Rolock engineers for recommendations. We can cut your heat-hour costs and improve processing. Catalog and Bulletin on request.

Offices in: PHILADELPHIA • CLEVELAND • DETROIT • HOUSTON • INDIANAPOLIS • CHICAGO • ST. LOUIS • LOS ANGELES • MINNEAPOLIS

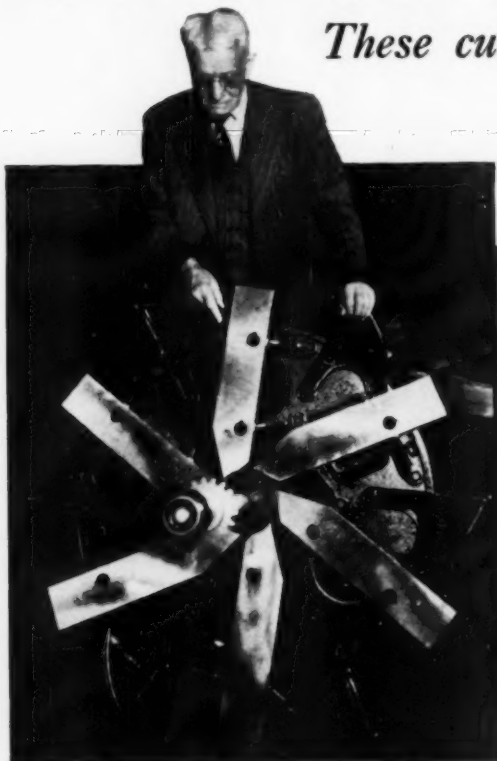
ROLOCK INC. • 1222 KINGS HIGHWAY, FAIRFIELD, CONN.

JOB-ENGINEERED for better work
Easier Operation, Lower Cost

26151

Now made of U.S.S

These cutter blades are tougher,



W. H. Preston, President of Papec Machine Company, examines the sharp edge on one of the six blades mounted on the cutting wheel of a Papec machine.



Because of the uniformity of CARILLOY 4150 blades, grinding of the beveled edges can be done with a multiple set-up on this Hanchett grinder.

Stones, wood, roots and even bits of metal pass through the spinning blades of Papec forage harvesters. Now made from heat-treated CARILLOY 4150, these blades are tougher than ever—and easier and cheaper to fabricate.



Carillo Steel...

harder—yet easier to fabricate

and cost 25% less!

SOMETIMES it costs less to use steel that costs more. Here's a case history to prove it.

Ensilage cutters and forage harvesters made by Papec Machine Company have long been regarded as tops in agricultural circles. The working heart of these machines are the cutter blades—and they really take a beating. When handling crops from stony fields, appalling amounts of stone along with wood, roots and bits of metal pass through the blades. To withstand abuse like this the blades *have* to be very tough indeed.

Papec formerly used a "laid-on" blade—a low carbon steel body with a high carbon cutting edge rolled on under high pressure and heat. These blades were good—but Papec wanted to make them better. So they called in our service metallurgist. Working closely with their engineers he finally found a way to greatly increase cutter blade durability. Now these vital parts are made of extra-tough, extra-hard alloy steel—heat-treated U-S-S CARILLOY 4150.

Simplified fabrication with
U-S-S Carillo 4150 cuts cost 25%

CARILLOY 4150 is plenty tough inside. Therefore it can safely take shocks that would ruin a more brittle blade. But it's also extremely hard on the surface—to furnish a sharp cutting edge that *stays* sharp. In other words, U-S-S CARILLOY 4150 provides the ideal combination of toughness and hardness that prevents damaged blades and time-wasting shutdowns.

In this application, CARILLOY 4150 does more than make a better blade—it speeds up fabrica-

tion, too. Testing it against air-hardening tool steel, Papec engineers found that, after heat-treating, CARILLOY 4150 showed all-round better characteristics and held a keen edge longer. The steel was also much more *uniform*. This uniformity paid off in two ways: First, the heat-treated CARILLOY blades were *easier* to machine. Second, the blades were less distorted after heat treatment, so *less* machining was required. As a result, the CARILLOY blades not only were much cheaper than air-hardened tool steel, but actually cost 25% less than the old "laid-on" blades.

Whatever properties your product needs—strength, toughness, light-weight, or superior durability under trying conditions—service-tested U-S-S CARILLOY Steels can provide them. And quite often at lower cost.

United States Steel Company
Room 4232, Carnegie Building
Pittsburgh 30, Pa.

☐ Please send me your book on U-S-S Carillo Steels.

Name

Company

Address

City and State

UNITED STATES STEEL COMPANY, PITTSBURGH • COLUMBIA STEEL COMPANY, SAN FRANCISCO

NATIONAL TUBE COMPANY, PITTSBURGH • TENNESSEE COAL, IRON & RAILROAD COMPANY, BIRMINGHAM

UNITED STATES STEEL SUPPLY COMPANY, WAREHOUSE DISTRIBUTORS, COAST-TO-COAST • UNITED STATES STEEL EXPORT COMPANY, NEW YORK



Carillo Steels

ELECTRIC FURNACE OR OPEN HEARTH • COMPLETE PRODUCTION FACILITIES IN CHICAGO AND PITTSBURGH

UNITED STATES STEEL

9-100

A HEAVY PRESS makes Light Work of Impression Die Forging

Ajax Solid Frame Forging Presses are engineered and built to produce impression die forgings of highest quality at new high rates of production and at a minimum cost. The great rigidity of the solid steel frame, the instantaneous response to the treadle achieved by the patented air clutch, the accuracy of slide alignment and

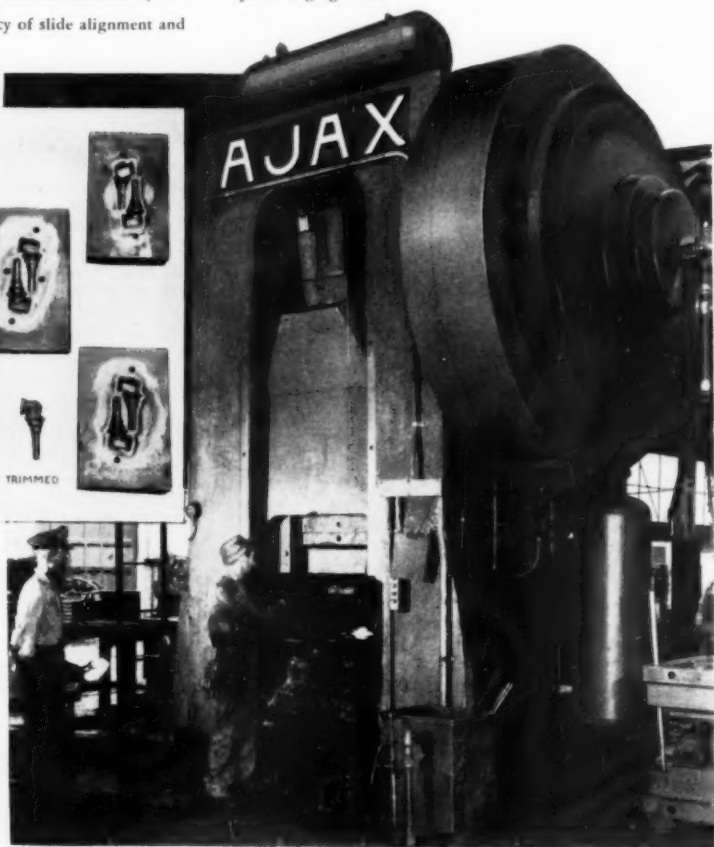
the minimized period of contact of the hot metal with the dies all contribute to making impression die forging easier and less costly than on slower, less rigid and less accurate presses . . . for impression die forging use an AJAX Forging Press.



Dies and Forging operations for forging tractor steering knuckles in pairs.

AJAX HIGH SPEED PRESS forging tractor gear blank at International Harvester Company, Louisville, Kentucky, Works.

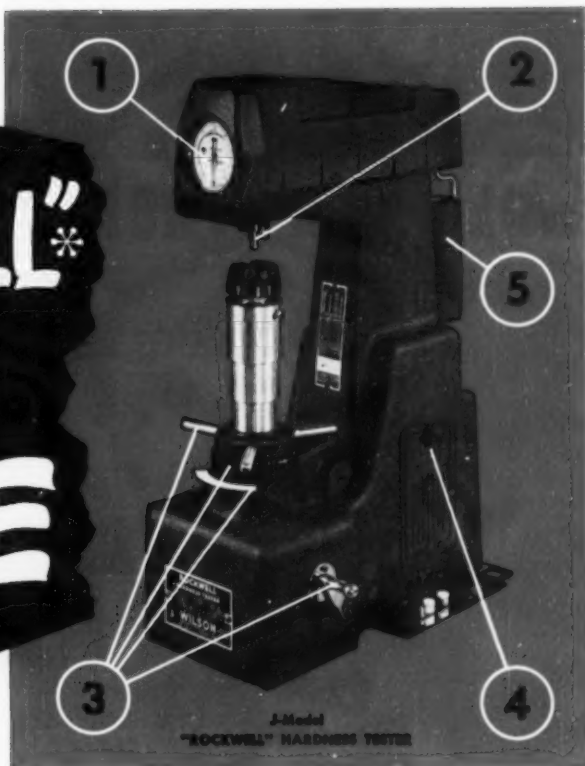
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THE **Ajax**

MANUFACTURING COMPANY
EUCLID BRANCH P. O. CLEVELAND 17, OHIO
110 S. DEARBORN ST. CHICAGO 3, ILLINOIS
DEWART BUILDING
NEW LONDON, CONN.

"ROCKWELL"^{*}
...to be
SURE



You NEED these features to assure accuracy and speed in hardness testing

- 1 Totally enclosed, dirt and dust-proof "Zerominder" dial gauge
- 2 Gripsel clamp screw for quick change and proper seating of penetrator
- 3 All controls grouped conveniently under capstan handwheel
- 4 Enclosed, easy-to-reach variable speed dash pot
- 5 Standardized weights

The J-Model improved "ROCKWELL" Hardness Testers have higher sensitivity, increased speed, are simpler to operate.

Most specifications today call for parts with certain hardness limits. If you test incoming materials, you know if they meet your production requirements. You know there will be fewer rejects. Then when you ship, you'll know that your customers will be satisfied.

"ROCKWELL" Hardness Testers are made in two types (Regular and Superficial) and many styles with accessories so they can be adapted to testing flats, rods, rounds, and odd shapes. There is also the TUKON for micro-indentation hardness testing. Tell us the nature of the test you contemplate, and we will recommend the machine best suited to the work.

*Trade Mark Registered

ACCO



WILSON

**MECHANICAL INSTRUMENT DIVISION
AMERICAN CHAIN & CABLE**

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**"ROCKWELL"^{*}
HARDNESS
TESTERS**

WHEN MORE PRODUCTION IS NEEDED

ACCOLOY

HEAT AND CORROSION RESISTANT

CASTINGS

*will give more years of
service even under the
toughest line schedules*

ALLOY ENGINEERING & CASTING COMPANY

ALLOY CASTING CO. (Div.)

CHAMPAIGN • ILLINOIS



ENGINEERS AND PRODUCERS OF HEAT AND CORROSION RESISTANT CASTINGS

NEW Streamlined AB SPEED PRESS



The most advanced design in press equipment for speed, convenience, and economy in the production of Bakelite and Transparent Molded Specimen Mounts ever presented to the metallurgist.

A revolutionary feature introduced in this new press is preheated Premolds. The preheat compartment reduces the curing time of thermosetting molds to one-third of the time usually required. It enables the operator to produce perfect Bakelite Mounts in 2½ to 3½ minutes. All necessary indicators and controls including pressure gauge, pyrometer, thermostats, timer and pilot lights are provided. No experience is required to produce perfect mounts. Automatic ram retraction saves time and effort.

The hinged press head is made with a semi-automatic lock and a hand wheel screw to close the mold securely. Heating blocks are arranged with a magnetic closure to snugly envelop the mold assembly. The interchange of thermostatically controlled heating units of 600 watt capacity is facilitated by convenient supports. Cooling blocks are located in a practical position in front of the press cabinet.

This new speed press is the result of long exacting experiment, with every effort devoted to designing the finest modern specimen press we are able to engineer.

No. 1330 AB Speed Press, complete for 1" mountings \$420.00
No. 1330-2 AB Speed Press, complete for 1½" mountings \$440.00
No. 1330-3 AB Speed Press, complete for 1½" mountings \$460.00

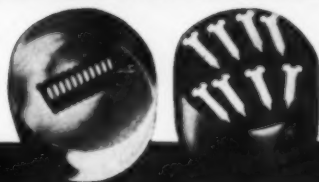
THE BUEHLER LINE OF SPECIMEN PREPARATION EQUIPMENT INCLUDES . . . CUT-OFF MACHINES • SPECIMEN MOUNT PRESSES • POWER GRINDERS • DISC GRINDERS • HAND GRINDERS • BELT SURFACERS • MECHANICAL AND ELECTRO POLISHERS • POLISHING CLOTHS • POLISHING ABRASIVES.

Buehler Ltd.

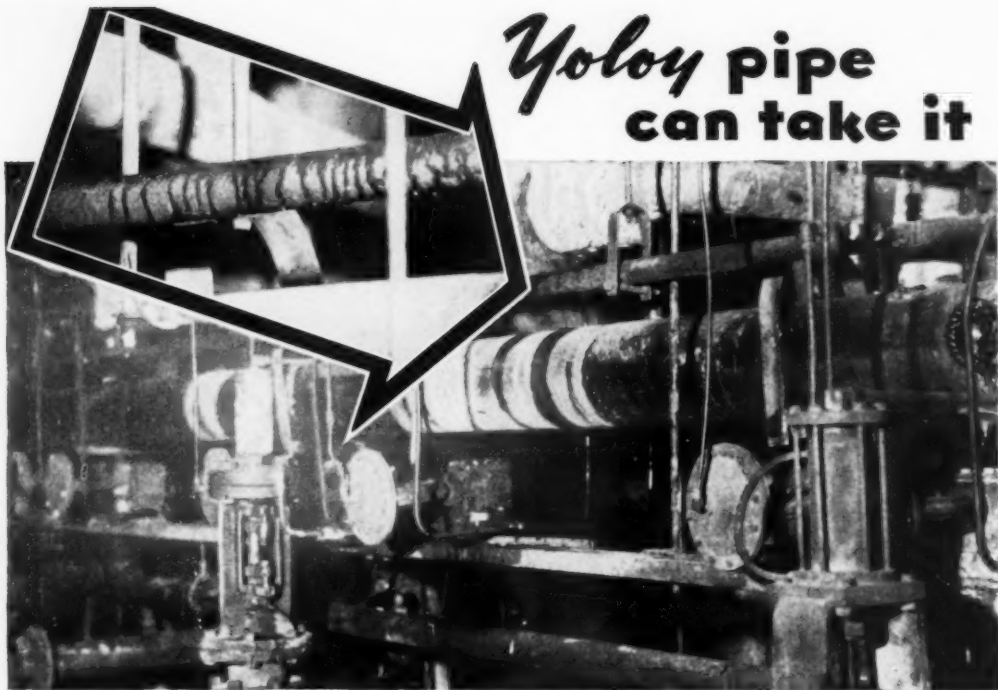
A PARTNERSHIP

165 WEST WACKER DRIVE CHICAGO 1, ILLINOIS

METALLURGICAL APPARATUS



Yoloy pipe can take it



In the arrow inset above, you see a piece of 1½" Yoloy Continuous Weld Pipe. Subject to continual corrosion, it is still in use after nearly 4 years. Regular pipe used here previously had failed and been replaced at least once a year.

This Yoloy pipe is in a booster pressure line carrying 500 P.S.I. raw cold water in an Akron rubber plant. It is in a humid basement, directly under the vulcanizers and subject to constant steam leakage and dripping, as is evident in the photograph. That Yoloy is outlasting regular pipe in this severe service is due to its unique nickel-cop-

per content or low-alloy composition.

In this installation Yoloy pipe has saved the manufacturer 50% of his pipe cost, 75% of his installation labor cost and has avoided three costly shutdowns for pipe repairs.

Yoloy standard weight black pipe is carried in stock for prompt delivery in sizes from ¾" to 3", inclusive. If you, too, want to save on your pipe costs, consider Yoloy. Get in touch with the nearest Youngstown District Office for complete information.



Youngstown

YOLOY STEEL PIPE

THE YOUNGSTOWN SHEET AND TUBE COMPANY

General Offices — Youngstown 1, Ohio

Manufacturers of Carbon, Alloy and Yoloy Steel

Export Office - 500 Fifth Avenue, New York

PIPE AND TUBULAR PRODUCTS - CONDUIT - BARS - RODS - COLD FINISHED CARBON AND ALLOY BARS - SHEETS - PLATES - WIRE - ELECTROLYTIC TIN PLATE - COKE TIN PLATE - RAILROAD TRACK SPIKES.

*Is this
Your Work?*

- ☐ Laboratory Melting
- ☐ Precision Casting
- ☐ Melting Gold, Silver, Platinum,
other precious metals
- ☐ Melting Non-Ferrous Alloys
up to 60 lbs.
- ☐ Melting Ferrous Alloys
up to 30 lbs.



Get Closer Control with this *FASTER* Ajax-Northrup 20-KW. Furnace

If your melting calls for a hard-boiled combination of melting speed, superfine control, and overall economy, this Ajax-Northrup 20 kw. converter-operated induction furnace can do the job. Melts 30 lbs. of brass in 20 minutes. 17 lbs. of steel in 35 minutes. No carbon contamination—no oxidation. Precise control of composition and temperatures . . . even with alloys that are "impossible" to handle in other furnaces.

Self-tuning. No adjustments required while melting. No moving parts to wear out. Maintenance is limited to annual inspection of two electrodes. Flexible . . . easy, quick changeover from one alloy to another. Built also in 3, 6, and 40 kw. sizes. Generator operated units to 1200 kw. and 8 tons. Send today for free bulletins covering any melting or heating problem.

AJAX ELECTROTHERMIC CORPORATION
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AJAX
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123

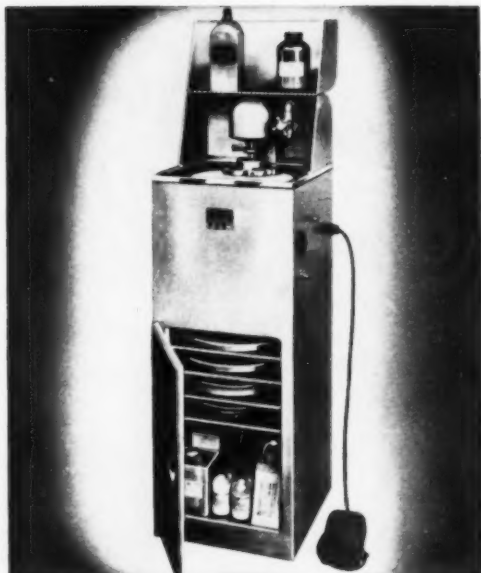
*This is
Your Bulletin*



HEATING
&
MELTING

March, 1951; Page 311

PRECISION Automatic Specimen-Polisher ideally completes 3-step technique (cutting, mounting, polishing) by *shearing*, not buffing or pulling, inclusions. Faster: about 30 minutes for 12 specimens. Uniform: no human variation. Lower cost: less skilled personnel-time, no spoiled specimens. Bulletin 5-513



**For New *ECONOMY*
in Laboratory Apparatus**

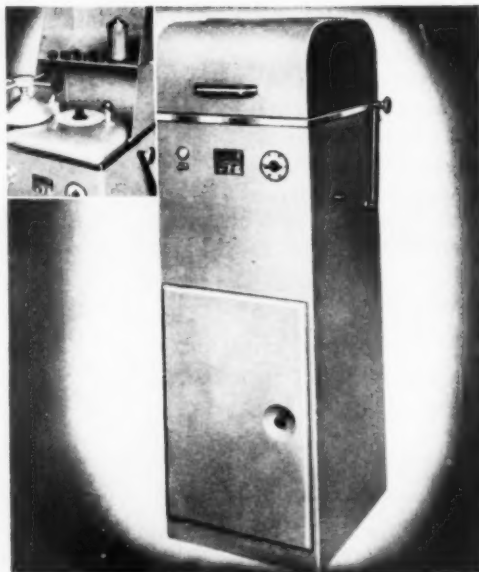
lower cost, more volume—

Specify

**Precision*

to be Sure

PRECISION Semi-Auto. Specimen Mounter for the second step in our noted 3-step technique. Self-contained unit with air-cylinder, automatically maintains pressure on specimen mount, relieves operator. Dual thermostatic heat control, pre-set air control, bell curing-timer. Saves space and trouble. Bulletin 5-713



To make your work easier, surer, more economical, replace or implement your present facilities with selections from some 3,000 Precision products. "Utility" items as well as highly specialized instruments are built beyond duty requirements.

Order from your Dealer NOW!

... or write us for details on above or your individual problem ... today.

Precision Scientific Company

3737 W. CORTLAND STREET—CHICAGO 47

*** FINEST Research and Production Control Apparatus**

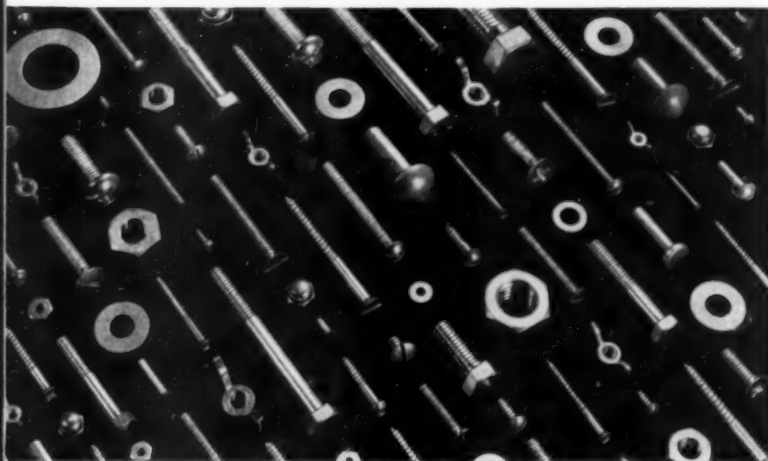
NEW YORK • PHILADELPHIA • ST. LOUIS • HOUSTON • SAN FRANCISCO

Metal Progress; Page 312

Aluminum

Government regulations limit the use of aluminum for other than essential projects. The facts presented here are to help you speed this essential work and get the most out of available metal.

It offers many an advantage, many a production short cut to designers and material specifiers in these pages, Alcoa presents some useful facts on it



CONTENTS

Aluminum Fasteners

Aluminum Castings

Aluminum Impact
Extrusions

Aluminum Forgings

Magnesium

ALUMINUM FASTENERS

They should be considered a must in all aluminum products they provide corrosion resistance with aluminum and also non-metallic assemblies

Beating corrosion before it starts is simple. Use aluminum fasteners with aluminum parts. You avoid galvanic corrosion which occurs when dissimilar metals are used. You avoid common corrosion from moisture and industrial atmospheres.

Frequently, product appearance is extremely important. Aluminum fasteners provide the closest color match with an aluminum assembly. They

are less visible under transparent lacquers. They are the only fasteners that will take an anodized finish to match your product.

Alcoa makes a complete line of aluminum fasteners. Samples may be obtained by writing to Alcoa. Alcoa makes special fasteners to your specifications and offers design help on questions of alloy selection, driving methods and use with other materials.

FOR FURTHER INFORMATION ON ALUMINUM PRODUCTS, TURN THE PAGE

Aluminum Castings

Competitively priced when final assembly costs are considered . . . they machine easily . . . often eliminate finishing . . . provide smooth surfaces as cast . . . in addition, they reduce costs of handling in production and shipping . . . their light weight contributes to the salability of the finished product . . .

ONCE you are satisfied that a light metal casting best meets the requirements of your product, you are ready to consider a source of supply.

Who has the capacity? Who can produce long

runs and tough jobs? How can you be assured that every advantage designed into your product will be delivered in the castings you buy?

Consider these facts about Alcoa . . .

Alcoa's several foundries are production foundries. The most modern equipment is available to turn your job out quickly . . . automatic molders, sand slingers, shake-out machines; There is ample capacity for scheduling your job immediately.

Quality control is as important to Alcoa as automatic equipment. The quality and soundness of your castings are guarded by thermocouple checks of pouring temperatures . . . competent supervision at every stage . . . critical inspection of sample lots by X-ray and magnaflux.

You can be sure of getting the right alloy because Alcoa developed most of the casting alloys in use today . . . 195, 212, 113, 132 and many others. Today's recognized light metal casting techniques began at Alcoa . . . fluxing molten metal to prevent gas absorption and to remove dissolved gases and entrapped dross, the use of rich alloys where alloying constituents are difficult to introduce in pure form.

Staffed by personnel who are old hands at casting light metals, backed by 63 years of light-metal experience, Alcoa foundries are located from coast to coast . . . can save time and shipping costs.



CONSTANT CHECK ON REMELT TEMPERATURE

is maintained by thermocouples suspended over the furnaces at this Alcoa foundry, one of the many assurances of sound, uniform castings.



**BROAD
EXPERIENCE,
BIG FACILITIES**

needed for difficult castings and long runs are available through these Alcoa foundries located at Vernon, California; Detroit, Michigan; Cleveland, Ohio, and Bridgeport, Connecticut.

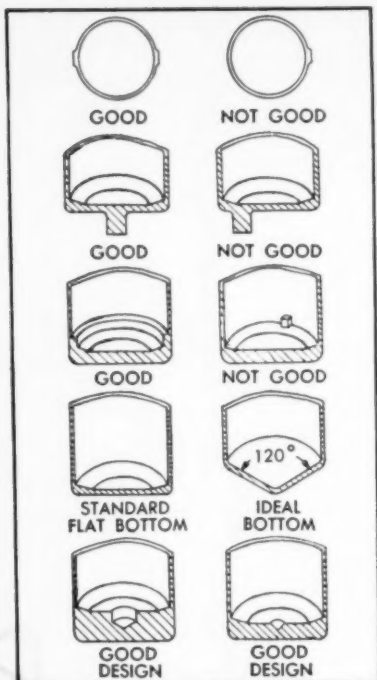
Aluminum Impact Extrusions

One of the fastest and most economical methods of producing cup-shaped or cylindrical parts . . . complete with ribs, cavities, and integral bosses . . . thin or heavy walls

Impact extrusions made by Alcoa permit designing products with fewer parts, greater strength, smoother surfaces, and lower manufacturing costs. Where parts include internal or external

ribs, bosses, integral flanged bottoms . . . or any element not readily formed or drawn . . . impact extrusion is often the best way to produce these parts.





Simple design precautions pay off

When designing parts for impact extrusion, remember that the process has a few limitations which can be avoided by attention to details like these . . .

Keep horizontal cross sections approximately symmetrical. This helps keep the punch centered . . . avoids variations in sidewall thickness.

Maintain a length-diameter ratio not greatly exceeding 6 to 1. Parts as large as 5 inches in diameter and 16 inches long have been successfully impact extruded. A good rule is to check designs with Alcoa's experienced extrusion engineers before departing from this ratio. They may be able to suggest slight modifications in your design that will result in major savings for you.

Be sure to specify the proper alloy. Alcoa specialists can help you. A minor compromise in physical properties, if necessary, might give you superior forming characteristics that can materially reduce your costs. Your local Alcoa sales office will gladly help you.

READ THIS BOOK! Alcoa would like to send you a copy of its 44-page booklet on aluminum impact extrusions. It will be helpful to you in designing parts. Just ask for a copy of "Alcoa Aluminum Impact Extrusions".

Aluminum Forgings

Strong . . . clean and smooth surfaced . . . free machining Alcoa forgings reduce weight and contribute substantially to compactness of design and to lower manufacturing costs . . . it is now possible to produce larger and more complicated forgings in aluminum than in any other metal . . . and at lower cost today than 10 years ago



To help you in designing for aluminum forgings, Alcoa offers a new book covering:

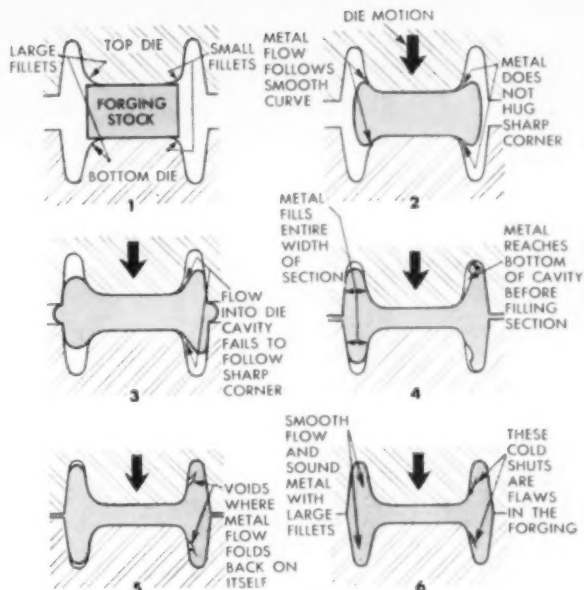
Relation of forging design to die sinking. Proper selection of draft angles and proportioning of web thickness, rib height, radii, etc., greatly affect the cost of sinking a die cavity.

Relation of forging design to the manufacturing process. A properly designed forging is one which meets functional

requirements, can be made in a minimum number of operations at the highest practical rate of production with minimum wear and tear on die equipment. The text covers manufacturing processes in detail, giving to the designer basic information which, applied to light alloy forging design, will help insure continuity of production at minimum cost.

In addition, a section on metallurgy gives all commercial alloy compositions, physical properties and commercial tolerances. A separate section covers the forging of magnesium alloys.

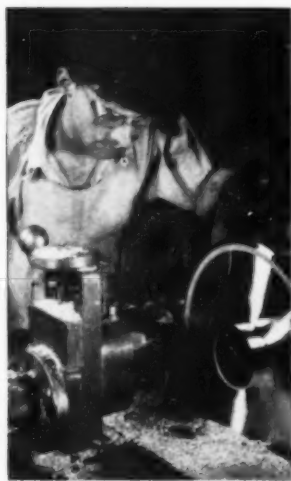
Alcoa makes forgings — drop hammer, press and hand forgings in both aluminum and magnesium. Alcoa forge shops are located in Cleveland, Ohio, and Vernon, California.



To illustrate the effect of fillet radius on metal flow, this forged section is shown with large fillets on the left side and small fillets on the right side. Progressive forging steps demonstrate how small fillets may cause unfilled sections, laps and cold shuts.

Magnesium

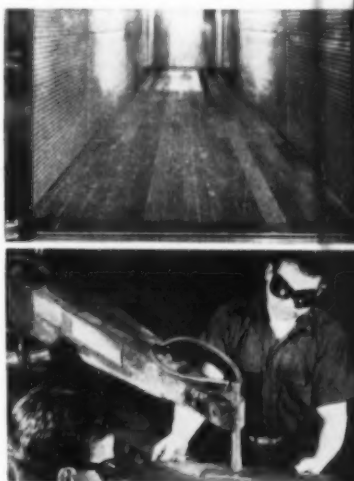
Weight for weight . . . about 18 times the stiffness of structural steel . . . about 2.5 times the stiffness of aluminum . . . its low specific gravity and low modulus of elasticity suggest design innovations



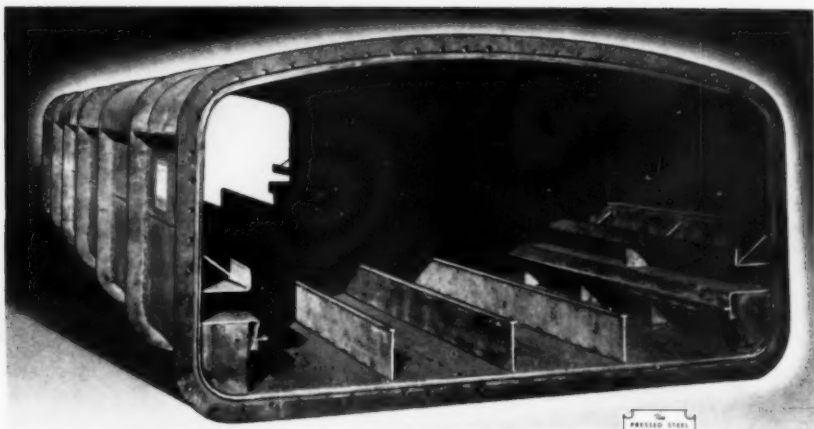
Magnesium is free machining. It can be machined safely at surface speeds impossible with other metals—rotary filing at 8,000 rpm, sawing at 15,000 rpm, lathe cuts at 5,000 rpm, face milling at 9,000 rpm, drilling at 2,000 rpm. Good house-keeping in the shop makes machining completely safe.

Magnesium has a low modulus of elasticity—6,500,000 psi. For this reason, it has remarkable ability to resist shock and impact. In designs calling for great resiliency as well as light weight, magnesium outperforms any other metal. A good example is the extruded magnesium trailer flooring shown here.

Magnesium has sufficiently low electrical conductivity, to make it an excellent material for light-metal parts that are to be resistance welded. Thicker sections can be joined in this fashion than with aluminum . . . and with smaller equipment.



ALCOA ALUMINUM PRODUCTS DESCRIBED IN THE FOREGOING PAGES ARE AVAILABLE THROUGH YOUR NEARBY ALCOA SALES OFFICE OR ALUMINUM COMPANY OF AMERICA, 1805B Gulf Bldg., Pittsburgh 19, Pa.



PSC

"LIGHT-WEIGHT" MUFFLES

CUT HEAT-HOUR COSTS

of controlled-atmosphere annealing



Above is a 40-foot muffle, made in two sections for ease of installation in a pusher-type annealing furnace of a leading brass manufacturer. 6 feet wide and 3 feet high, the sections were bolted together at the flanges. The unit was entirely fabricated of 1/4" alloy to give the economies of PSC "light-weight" construction. Although a set operating study has not been made, our customer reports a substantial saving in fuel and heating time.

The above muffle was fabricated of 12-14 alloy, for low-temperature gas-fired annealing (up to 1250°). PSC muffles are furnished in any desired alloy, for temperatures to 2200°; in any size and for any type furnace.

In cases of special furnaces, limited space and other situations, the design of a muffle becomes a prime factor in successful operation of the furnace. To assure you uniform controlled heating as well as strength and long life, we invite you to take advantage of our over 20 years experience in designing and fabricating a complete line of heat-treating carriers. Write as to your needs or for address of your nearest PSC representative.



THE PRESSED STEEL COMPANY

of WILKES-BARRE, PENNSYLVANIA

*Industrial Equipment of Heat and Corrosion Resistant WEIGHT-**SAVING** Sheet Alloys*

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Neonations

METAL FINISHING...



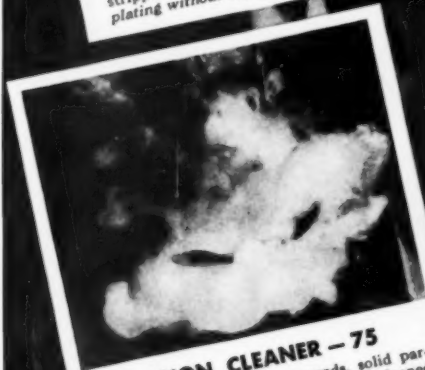
METAL STRIPPER — A

An outstanding development for stripping defective electroplated nickel, copper, silver, cadmium and zinc from steel. Fast action... no basis metal attack. The highly polished grill cover illustrated has been completely stripped of nickelplate, and is ready for replating without repolishing.



EBONOL BLACKENING PROCESSES

Ebonol finishes are used to beautify a widely diversified list of superior quality products. Photo shows steel parts blackened with Ebonol-S and S-30; copper and brass with Ebonol-C; zinc with Ebonol-Z. U. S. Patents — 2,364,993, 2,460,896, 2,460,898.



EMULSION CLEANER — 75

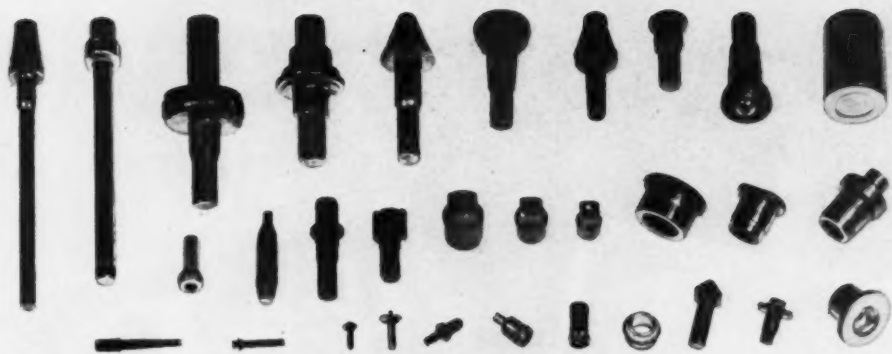
Oils, greases, buffing compounds, solid particles, deep seated in steel parts are cleaned out and completely removed by this emulsification process. Stubborn, gummy substances on die castings, milling machines, floors, motor blocks emulsify and disperse in water instantly.



ENAMEL STRIPPERS

Enthone has over 20 strippers for removing organic finishes — synthetic enamels, lacquers, vinyls, japans. The best strippers, tailor-made for your particular problem, are selected by laboratory technicians after test runs. This service is rendered free of charge.

Enthone Incorporated

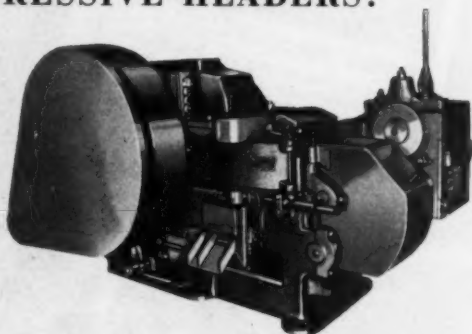


COLD-FORGE YOUR "GADGETS" ON NATIONAL PROGRESSIVE HEADERS!

Multi-Station Machine Produces
Close-Tolerance Parts *Seven to
Fifteen Times Faster Than*
Machining Methods . . . Reduces
Material Waste Up to 50% . . .

National Progressive-Type Headers are
considered "The Gadget-Makers of Cold-
Forging" because their range includes a
wide variety of odd-shaped metal parts.

In the Progressive Header Method, the
blank is cut off and progressively trans-
ferred through two or more sets of punches
and dies, producing work previously
considered too complex for high-speed
cold-forging.



If your work involves double and triple
extrusion—or multiple heading in two
or more die impressions—then it is espe-
cially suited to the National Progressive
Header Method.



THIS DOOR IS ALWAYS OPEN

Let us help you apply National's experi-
ence in hot and cold forging to your jobs.
Send us prints or samples of your work, or
better yet, pay us a visit. No obligation.

NATIONAL

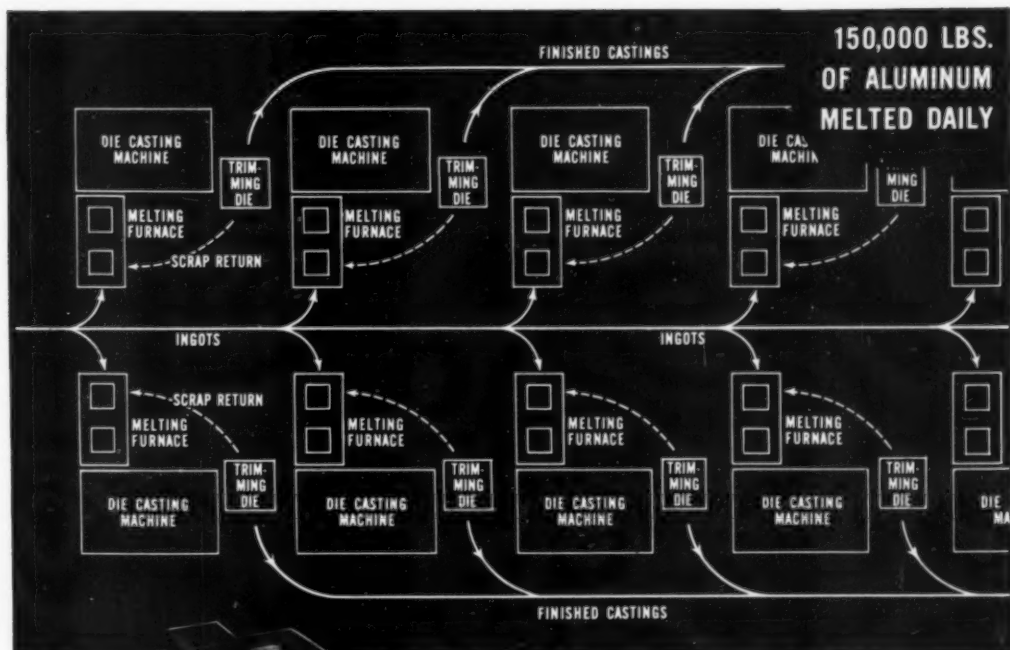
MACHINERY COMPANY
TIFFIN, OHIO.

DESIGNERS AND BUILDERS OF MODERN FORGING MACHINES—MAXIPRESSES—COLD HEADERS—AND BOLT, NUT, RIVET, AND WIRE NAIL MACHINERY

Hartford

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15 LINDBERG 2-CHAMBER FURNACES IN ONE DIE-CASTING PLANT....

One of the nation's newest die-casting plants uses 15 Lindberg Two-Chamber Furnaces in their die casting operations. These furnaces, operating on a 24 hour a day schedule have the capacity to melt 150,000 lbs. of alloy per day. Each furnace serves a separate die casting machine to produce these production advantages . . .

No melting room needed—all metal is melted at the casting machine, eliminating the need for carrying hot metal through the plant.

No scrap sorting—scrap metal and reject

castings never leave the machine, allowing the use of a different alloy in each machine if necessary, while completely eliminating scrap sorting, handling and identification problems.

Unified production unit—each die casting machine becomes a unified production unit—receiving cold alloy ingot, melting, holding, casting, inspecting, reclaiming scrap metal and reject castings—delivering only the finished casting to the production line. Obviously the savings realized are spectacular.

LINDBERG-Fisher **MELTING FURNACES**

Lindberg Engineering Co., 2448 W. Hubbard Street, Chicago 12, Illinois

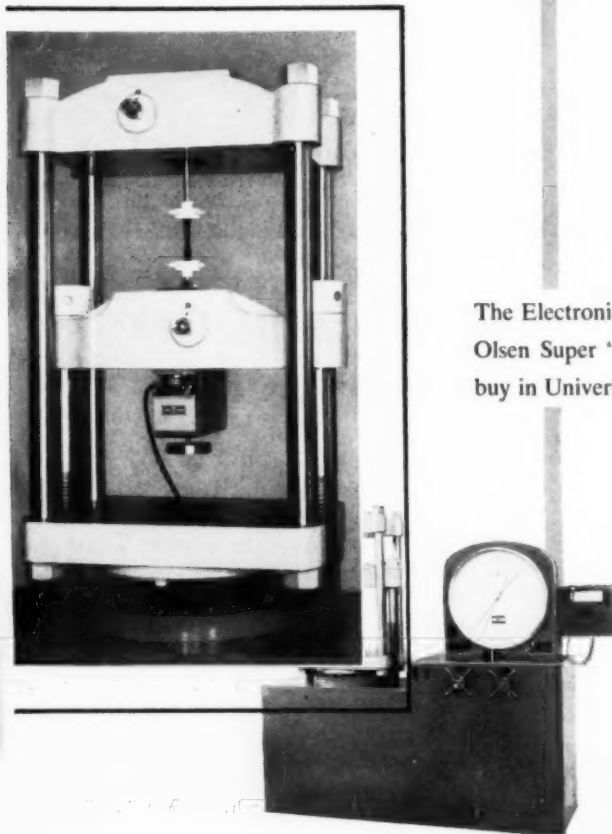
March, 1951; Page 315

new

OLSEN ELECTRONIC LOAD CELL

provides

1000 to 1 extra low range



New Olsen 200,000 lb. Super "L" with SelectoRange indicating system. Electronic load cell illustrated above.

Just attach it to the crosshead of the new Olsen Super "L" with SelectoRange indicating system, and plug it in—and you have the use of a highly accurate "super low" (1000 to 1) testing range. You can read by 1/4 lb. marks on a 200,000 lb. machine when using a 200 lb. cell which is connected directly to the dial indicator.

This completely new load cell which employs an "atcotran" differential transformer, is a compact unit built into an auxiliary weighing system. Available in a range of capacities, the Olsen Electronic Load Cell may be used for compression or tension testing, and with or without an electronic recorder. Construction is simple, installation is a matter of but a minute or so, operation is elemental, and there is nothing to get out of order.

The Electronic Load Cell is another reason why the Olsen Super "L" is today's "way out in front" best buy in Universal testing machines.

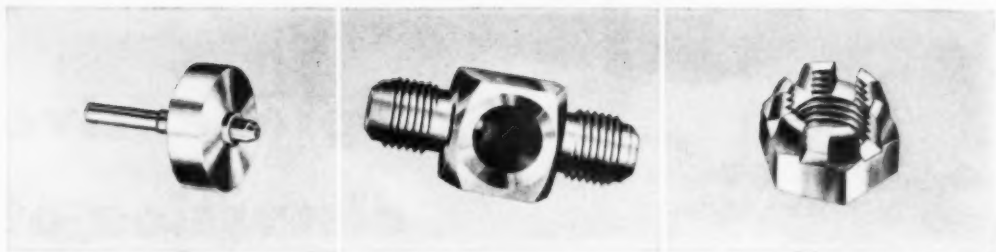
*Write today for information
about both the Super "L"
and the Electronic Load Cell.*

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Testing & Balancing Machines

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These are not unusual job records. The reason for performance records such as 10% faster machining and 5% to 8% fewer rejects is the *constant uniformity* of Carpenter Free-Machining Stainless. Every bar, on shipment after shipment of Carpenter Stainless, responds the same when it meets your cutting tools.

Under today's conditions, it is important that you get every possible finished part from the Stainless Steel you buy. To do that . . . to find new ways to turn Stainless jobs out faster and better . . . make use of the personal shop help your Carpenter

representative can give you. He will be glad to work with you and your men, to make his experience stretch the available supply of Stainless Steel.

Another help Carpenter can give you is useful information about machining Stainless. For example, the Carpenter "NOTEBOOK on Machining Stainless Steels" covers turning, drilling, reaming, lubrication, etc. If you would like a copy, just send us a note on your company letterhead, indicating your title.

The Carpenter Steel Company, 133 W. Bern St., Reading, Pa.
Export Department: The Carpenter Steel Company, Reading, Pa. — "CARSTEELCO"



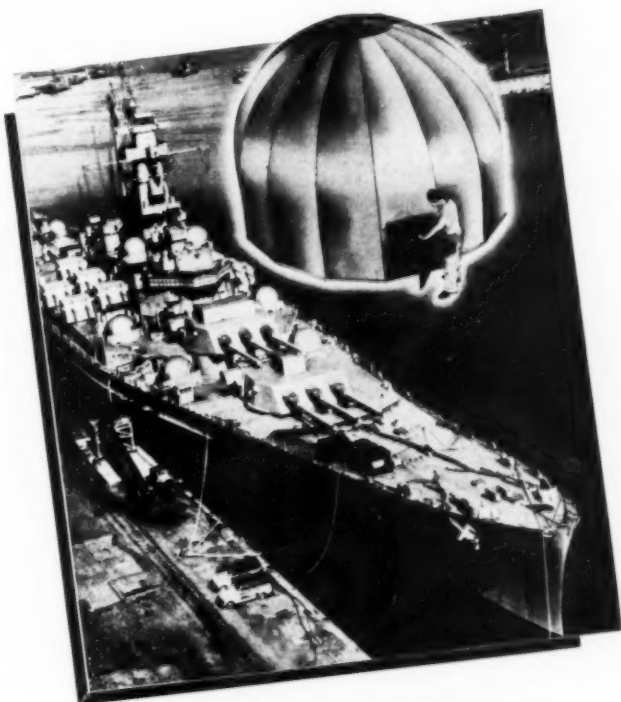
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STAINLESS STEEL

takes the problems out of production

For Easy-to-Use Stainless Call Carpenter. Warehouses in principal cities throughout the country.

Metal Progress: Page 318



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Whether it be prime defense work or peacetime production, Brandt is ready with several hundred thousand square feet of mass production facilities, giant equipment and a versatile organization at your service.

STAMPINGS, SPOT WELDED ASSEMBLIES, WELDMENTS and PRESSED STEEL SHAPES in all types of metal.

BRANDT ENGINEERS WILL EXPEDITE YOUR INQUIRY.

Get your copy of this Engineers' File of Brandt contract manufacturing facilities.

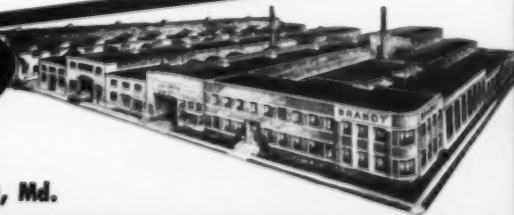


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BALTIMORE

CHARLES T. BRANDT, INC.

1700 Ridgely Street, Baltimore 30, Md.



ALSIFER

effects grain refinement

of steel

For grain refinement and grain size control of wrought steels made by both open hearth and electric furnace practice, Alsifer... a well-balanced, carbon-free alloy of approximately 40% iron, 40% silicon and 20% aluminum... offers several distinct advantages.

First—a new feature—Alsifer is now chill cast into pigs to make it more dense and to give it high specific gravity, resulting in higher efficiency and greater economy for the steelmaker.

Second—the high specific gravity of this alloy insures rapid and complete penetration of the slag and metal when Alsifer is added to the ladle or furnace.

Third—its use promotes higher recovery and better control of grain size and deoxidation, with uniform results assured from heat to heat.

Alsifer is produced in electric furnaces under rigidly controlled conditions that give this alloy exceptional uniformity. It is supplied in sizes to meet all metallurgical requirements.

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MAKERS OF ALLOYS



CHEMICALS AND METALS



Don't buy heat treating equipment blindfolded! Results obtained on sample batches of your products in this shop and upon Ajax Metallurgical Service Laboratory can be duplicated in your own plant.

Say Goodbye to Guesswork

ON HEAT TREATING RESULTS AND COSTS!

Without charge or obligation, the Ajax Metallurgical Service Laboratory will treat specimen parts by any of the following processes:

CARBURIZING
CYANIDE HARDENING
NEUTRAL HARDENING
ANNEALING OR HARDENING
STAINLESS STEEL
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STEEL
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MARTEMPERING
PROCESS ANNEALING
CYCLIC ANNEALING
SOLUTION HEAT
TREATMENT
DRAWING (Tempering)
DESCALING CLEANING
DESANDING

What about the quality of the finished work? Will it be scale-free, devoid of decarb? Will the heat treatment prevent distortion and thereby reduce or eliminate costly grinding or finish machining operations? How much production will the furnace give per hour, and what floor space will be needed? What will the power, labor, maintenance and other heat treating costs amount to? In short, will our proposed new furnace live up to the manufacturer's enthusiastic claims for it?

You can be absolutely sure on all of these points before you buy an Ajax Electric Salt Bath Furnace for these reasons:

1—No Ajax salt bath furnace is ever sold until Ajax engineers—backed with experience in over 3,000 installations—are convinced it will do the job to your entire satisfaction as well as to theirs.

2—Before buying, we strongly urge that you utilize the facilities of the full commercial scale Ajax Metallurgical Service Laboratory. Send or bring batch lots of your materials for heat treating under actual working conditions. Let us prove beyond any question of doubt what can be done, how it can be done, and under exactly what conditions.

3—Once your furnace is installed, an Ajax engineer will visit your plant to double check, instruct, and to make sure that on-the-job operation fully matches our expectations.

This policy has resulted in the most outstanding patronage ever accorded any heat treating furnace, both as to the importance and number of users. A list of users is available on request. The high percentage of customers who have re-ordered Ajax heat treating equipment is unparalleled in the furnace industry.

AJAX ELECTRIC COMPANY, Inc.

World's Largest Manufacturer of Electric Heat Treating Furnaces Exclusively
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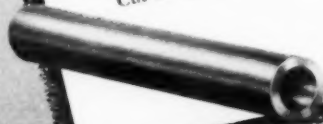
ELECTRIC SALT BATH FURNACES

2 MILNE WAYS TO CUT YOUR TOOL STEEL COSTS

2 MILNE'S HOLLOW DIE STEELS

You get more tool per pound when you use Milne hollow steels. Waste is minimized. Smooth finish inside and out saves hours of machining. Each piece is uniformly annealed at the mill. Prompt deliveries from stock. Eliminates waiting for forgings.

Cut to any length desired.



1 MILNE'S KOLORKOTE IDENTIFICATION

With Matching Heat Treat Card

Permanent, quick-as-a-glance identification of Milne tool steels is a sure thing because they are spray painted an identifying color over their entire length. With every shipment goes a heat treatment card of a color that matches the steel. You eliminate costly errors, delays, confusion and phone calls. Inventory control, scrap identification and stock movements are simplified.

You know what you get...how to treat it...as long as you have it.

NOT JUST
THE ENDS



VISIT US at Booth #520 during the WESTERN METAL CONGRESS & EXPOSITION, Oakland, Cal., March 19th through 23rd, and get the complete story on

MILNE'S

New Pre-Shaped Steels

These are special cold drawn sections that start where machining often leaves off... make many machining operations obsolete.

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up 2100%

with TOCCO* Induction Heating

MACK MANUFACTURING CORPORATION builders of famous Mack Trucks, switched from carburizing to TOCCO induction hardening their brake cams. Result: Production up from 11 to 240 parts per 8 hour shift.

SAVES MONEY—At the same time TOCCO brings costs down 15¢ on the small brake cam shown here—57¢ on the larger cam—an average savings of over 10%.

SAVES LABOR—The TOCCO machine is operated by one man—eliminates the use of three to five men in the heat treat department, frees three furnaces for other production.

SAVES HANDLING—Moreover the TOCCO machine is set in line with machining operations, eliminates 1200-foot haul to and from heat treat department.

Why not let a TOCCO engineer show you how TOCCO can cut your hardening, brazing or forging costs and speed up your production? No obligation, of course.

THE OHIO CRANKSHAFT COMPANY



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Please send copy of 60-page catalog "TOCCO Induction Heating."

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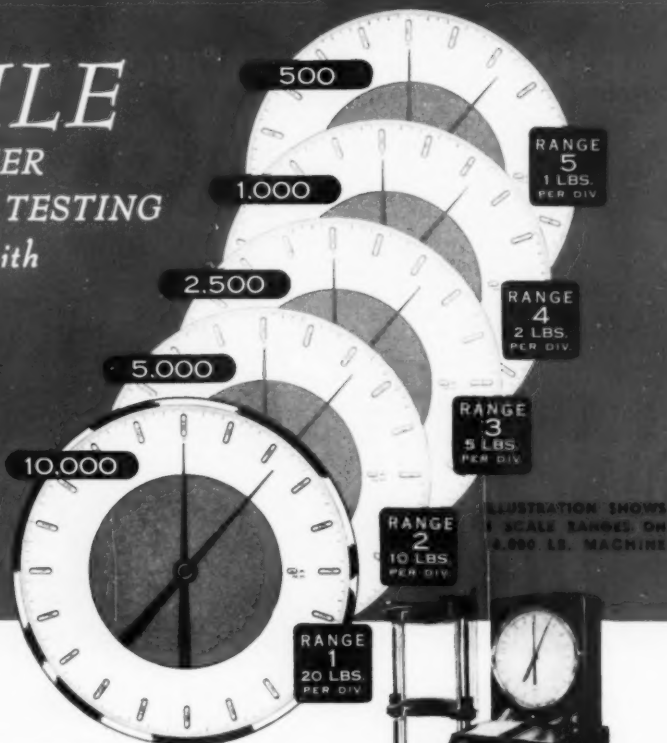
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5 SCALE RANGES

PRECISE LOAD
INDICATION FOR
ALL YOUR TESTS



BUILT IN 11 SIZES

2,000 LBS.	30,000 LBS.	160,000 LBS.
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Only Riehle gives you 5 separate ranges in every Screw Power Universal Testing Machine . . . the equivalent of 5 complete machines in 1.

5 scale ranges give you precise coverage over the machine's full capacity and permit you, by a turn of the range selector knob, to choose the range most applicable for any given test.

"ONE TEST IS WORTH A THOUSAND EXPERT OPINIONS"

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ACCURATE-CONVENIENT-DEPENDABLE

Other Riehle features you'll like are the fool-proof Pendomatic Indicating Unit . . . accuracy guaranteed within $\frac{1}{2}$ the normal tolerance allowed by ASTM and Federal specifications . . . exceptionally low weighing table . . . low over-all height . . . easy installation and distinctive streamlined appearance.

NEW ILLUSTRATED CATALOG

Send today for 28-page catalog, covering all Riehle Screw Power Universals. Contains illustrations, features, operating details, specifications.

Engineering Digest of New Products

LOW-COST TESTING MACHINE: Tinius Olsen Testing Machine Co. announces manufacture of a completely new line of low-cost hydraulic testing machines for simplified, accurate tension, compression, transverse and flexure testing. Designated the



Super "L", these testing machines feature the new Selectorange indicating system with Atcotran unit which makes possible a 50-to-1 spread of testing ranges on one 28-in. dial. This indicating system is entirely separate from the loading system in that the load is developed hydraulically and is measured and indicated electronically. All three test ranges of the Super "L" — full, 1/5 and 1/50 capacities — are indicated in three different colors on the same dial of the indicator with zeros for all ranges being identical. Selected load ranges are automatically illuminated as to capacity, value of one division and as to color. Since zero loads of all ranges are identical, test ranges may be changed during a test without changing the rate of loading.

The 60,000-lb. machine has additional ranges of 12,000 lb. by 20-lb. dial marks and 1200 lb. by 2-lb. divisions. Top range is indicated by 100-lb. graduations. A range of testing speeds from 0 to 2 in. per min. is obtainable in stepless intervals by using a dual valve system which also applies, removes or holds loads constant. Simply and ruggedly constructed,

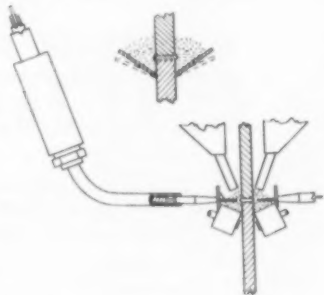
these low-cost machines are provided with hydraulic safety valves and stroke limit switch to prevent overloading and overtravel. By using an Olsen electronic recorder in conjunction with these machines, testing ranges may be increased to a ratio of 100 to 1.

For further information circle No. 180 on literature request card on p. 328B

WELDING PROCESS: Automatic hidden-arc welding has been limited in application to jobs where the joint to be welded is in position for downhand welding. A new process, developed and patented by The Lincoln Electric Co., removes this limitation and extends the advantages of automatic hidden-arc welding to jobs where the joint is in other positions. This process consists of new welding methods, procedures and equipment wherein the previous difficulties of directing the electrode and of retaining flux and molten metal in a joint not lying flat are overcome. With this process the plate being welded may be positioned anywhere from flat to vertical, the joint being horizontal.

The new process, referred to as "3 o'clock" welding, greatly reduces the cost of welding and expands the possibilities for the application of hidden-arc techniques. Because joints can be positioned horizontally, welds from both sides of the joint can be made simultaneously. This reduces actual arc time on a given joint by about 50% and results in lower direct labor costs. Positioning each weld for downhand welding is eliminated, thus reducing handling and set-up time. In addition to reducing direct labor costs, savings are made because of the smaller sizes of electrode wire used. For example, where on a downhand application a $\frac{1}{8}$ -in. diameter electrode would be used, in a "3 o'clock" position a $\frac{1}{16}$ or $\frac{3}{32}$ -in. electrode is used. This means that lower currents are used, less electrode is required, smaller quantities of flux are consumed, welds of reduced cross-sectional area are made, thus wasting less metal in unnecessary buildup. Welds can be

made in either straight seams or following an irregular contour. Other advantages of the new process are a minimizing of the effects of distortion and the causes of weld cracking. Tendency for burn-through is reduced and backup strips can be eliminated



where two arcs on opposite sides of the work are used. The process is ideal for applications such as fabricating pipe, box sections, special I-beams and H-sections, joining clips to automobile bumpers, field erection of large outdoor storage tanks, farm machinery parts and other machine frames.

For further information circle No. 181 on literature request card on p. 328B

WAX FOR DRAWING-LUBRICANT: S. C. Johnson and Son, Inc., have announced that special blends of waxes used in place of conventional lubricants permit the drawing of stainless steel far beyond its theoretical capacity. They may also serve as a replacement for the copper flashing on stainless steel wire used for cold heading. Wax blends are also proving useful in drawing of aluminum. The use of wax as a lubricant extends the life of tools and dies and may completely eliminate degreasing. Still another use for wax in metal fabricating has been adopted by a screw manufacturer after it was determined that the torque of self-tapping metal screws could be reduced by 50% if the screws were given a coating of the special wax blend. A

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—see for yourself why more and more finishers of aluminum products are specifying Iridite Al-Coat for any wrought, cast or buffed aluminum part.

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Faster—Just one simple dip, 10 seconds or only two minutes, depending upon your finishing specifications. No sealing dip, no special drying.

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Paint Base—Blocks underfilm corrosion; grips paint, holds it firmly.

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Conductivity—Offers low surface resistance to electrical current.

4. IN COST

Comparative figures show that Iridite Al-Coat saves as much as 50% over other aluminum finishing processes. *Let us prove this to you.*

Write today for **FREE SAMPLES** of Iridite Al-Coat. Or, send samples of your product for test processing.

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New Products

major aircraft company is successfully using wax as a lubricant in the shoe bending of a hard alloy tube. Wax not only reduces the bending pressure from 4 to 2½ tons, but also reduces the loss from crimping and buckling. For further information circle No. 182 on literature request card on p. 328B

BLAST CLEANING: A new midget unit by Pangborn Corp., for liquid blast cleaning, weighs only 40 lb. (where aluminum can be used for the main housing) and is operable from either a ¼-in. compressed air line or any bottle of compressed gas. In metalworking and machinery perhaps the principal fields of usefulness for the new machine will be: (a) die and mold polishing after heat treatment, (b) precision part polishing, (c) surface treatment to hold light lubricating oil films better, (d) preparation for plating, (e) tool and fixture maintenance and cleaning, (f) cleaning of parts which function at high temperatures (e.g., spark plugs) and (g) stain and light scale removal. The new unit uses the same wide range of abrasives (as fine as 5000 mesh) as its larger brothers, and can hold tolerances on blasted parts to within 0.0001 in. It requires only 17 x 22½ in. of floor space, uses 110-volt a. c. to drive its filter and dust bag motor, and consumes from 5 to 20 cfm. of air at 80 psi.

For further information circle No. 183 on literature request card on p. 328B

RUST PREVENTIVE: A new addition to its line of No-Rust compounds has been announced by the Gulf Oil Corp. The new No-Rust No. 6 is recommended for protection of metal surfaces against corrosion in either indoor or outdoor exposure during domestic and overseas shipment and for either indoor or outdoor storage for long periods of time. It is a rust preventive of the thin film type, providing approximate surface coverage of 390 sq. ft. per gal., and will not crack, chip, scale or disintegrate at temperatures down to 0° F., nor will it flow at temperatures as high as 190° F. It is suitable for application by brushing, spraying, or dipping and is readily removed with stoddard solvent, kerosene, or similar petroleum solvents.

For further information circle No. 184 on literature request card on p. 328B

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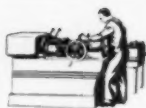
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TIPS ON TAPPING AND THREADING TROUBLES



DATA

Page A-6

● OILS FOR TAPPING AND THREADING

Oils With Active Sulphur Required
Tapping and threading are difficult machining operations due primarily to limited chip room and the difficulty of maintaining sufficient lubrication at points of contact between threading tool and workpiece. Cutting oils having high sulphur activity are usually required and recommended for difficult threading and tapping work. Stuart's THREDKUT and related products, due to their high effective sulphur content, have been outstanding for this class of work. Active or effective sulphur in an oil functions as an anti-weld agent preventing pick-up of metal particles on the tool which results in scuffing and poor finishes.

● Rule of Thumb

Here is a good rule of thumb to remember when sulfurized cutting oils are being used:

- When you observe excessive wear on the front clearance of cutting tools, **DECREASE** the amount of active sulphur in the oil by diluting with paraffin oil or other low cost blending oil. If poor finish is encountered due to welding or metal pick-up on the tool edge, **INCREASE** the active sulphur, or if Stuart's THREDKUT is being used, apply it straight.

RESULTS

Operation: Threading male pipe union sections on large automatics using single point tools.

Material: Type 310 stainless steel.

	Stuart's THREDKUT 9961	
	Previous Oil	
Tool Life:	135 pcs. per tool grind	310 pcs. per tool grind
Part Finish:	Fair	Excellent
Cutting Fluid Costs on Machine:	\$8.47 per gal.	\$8.44 per gal.

Write for literature and ask to have a Stuart Representative call

D.A. Stuart Oil Co.

2743 S. Troy St., Chicago 23, Ill.

Engineering Digest of New Products

ABRASIVE CUTTING MACHINE:

Campbell Machine Div. has announced a new wet abrasive cutting machine, Model 508. This machine will cut solid round bars up to 8-in. diameter and tubing up to 8-in. o.d., either ferrous or nonferrous, including stainless as well as hardened or annealed steel. It is a revolving work bar type of machine with oscillating abrasive cutting wheel, hydraulic wheel feed and hydraulic work clamps.

For further information circle No. 185 on literature request card on p. 328B

ARC WELDERS: Three new arc welders, available as indoor or all-weather models, have been announced by Air Reduction Sales. Outstanding features include instant arc-starting wide current range, easy-to-operate controls and minimum maintenance. Current ranges are 60 to 375 for the 300-amp. model, 80 to 400 for the 400-amp. model, and 100 to 675 for 500 amp. The silicone insulation operates safely at high temperatures without breaking down and is water repellent. Because there are no rotating parts, with the exception of the fan on the 400 and 500-amp. models, maintenance costs are low.

For further information circle No. 186 on literature request card on p. 328B

CARBON TEST: Carbon in mild steel baths may be determined in less than 1 min. by a test now available from the Harry W. Dietert Co. Under the

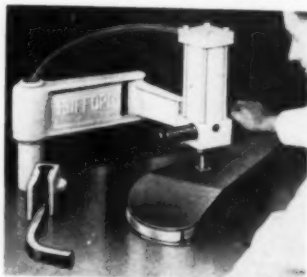


controlled conditions of the test, a hardness tester graduated in per cent carbon gives carbon results to within 0.02% in the range between 0.05 and 0.45% carbon. The equipment is designed to give long service directly on the melting floor. Valuable furnace time may be saved by eliminat-

ing waiting time for laboratory preliminaries. The test may be applied to any nonaustenitic steel up to 0.60% carbon.

For further information circle No. 187 on literature request card on p. 328B

FINISHING MACHINES: Two new machines especially designed for easing the manufacture of sheet metal parts have been developed by Hufford Machine Works, Inc. One, a shrink finishing machine, removes wrinkles from parts that have formed on rubber pad presses. It employs a mechanically driven lead "slapper"



which eliminates all manual effort. A foot pedal releases air to a pneumatic clamp which secures the part and its respective form block to the steel table top during the process. After the first few blows, the slapper conforms over its entire length to the shape of the work. After the shrinking operation, the work and form block are taken to the Hufford planishing machine. This incorporates an air-driven hammer assembly mounted on a smooth table top. The hammer is activated by pressure of the work against the head itself. A series of short, rapid blows quickly remove minor defects, producing a smooth, finished surface.

For further information circle No. 188 on literature request card on p. 328B

DRILL: A new carbide drill for drilling heat treated steels, developed by Super Tool Co., features a long solid carbide end which tends to keep the heat, developed in cutting, well away from the braze. This eliminates many failures that result from tips loosening from the body, particularly in the smaller diameters where it is difficult to braze securely.

For further information circle No. 189 on literature request card on p. 328B

190. Alloy Annealing Slide Chart

Annealing data for the principal analyses alloy steels is contained in a convenient slide chart. On one side is listed data for producing spheroidal structures in 40 alloy types by the conventional and isothermal annealing process. The reverse side carries data for producing lamellar structures, also broken down by conventional and isothermal processes. *Republic Steel Corp.*

191. Alloys

New catalog, "Electromet Ferro-Alloys Metals", lists over 50 metals and alloys and describes unique technical services offered to metal industries. *Electro Metallurgical Div.*

192. Alloys, Fabricated

Catalog available showing cost-cutting fabricated heat treating equipment for higher loads and better quality. *Rolock, Inc.*

193. Alloys, Nickel

New technical bulletin T-6 discusses resistance of nickel and its alloys to corrosion by caustic alkalis. *International Nickel Co.*

194. Aluminized Steel

Illustrated 24-page booklet, "Armco Aluminized Steel", describes this steel's aluminum face, its heat and corrosion resistance and standing heat reflectivity 80% up to 900°. Photographs of a wide variety of applications included with data on mechanical and form properties. *Armco Steel Corp.*

195. Aluminum Coating

Reprints now available on Dooty Spruance article, describing protection of aluminum alloy by amorphous phosphate coatings which also give good surface for paint adhesion. *American Chemical Paint Co.*

196. Aluminum Tubes and Shapes

New price list available on aluminum tube and extruded aluminum shapes, rods and bars. *Revere Copper and Brass, Inc.*

197. Belts, Metal

Bulletin 47P illustrates and describes complete line of wire belts for industry. *Ashley Brothers, Inc.*

198. Bending Metal

"It's Easy to Bend" is the title of a 32-page bending manual containing numerous illustrations showing D-I-Acro Benders in operation. Valuable information applies to any rolling bending machine. *O'Neil-Irwin Mfg. Co.*

199. Beryllium Copper

Helpful engineering information contained in new monthly series of Beryllium copper technical bulletins. *Beryllium Corp.*

200. Blast Cleaning

There is a Panaborn rodblast table, box or table-room designed to bring you amazing savings. Write for bulletin 214. *Panaborn Co.*

201. Bronzes, Cast

New catalog ready on Asarco Continuous Cast Bronzes contains physical properties, photographs, table of stock shapes and sizes, weights and other valuable information. *Asarco Smelting & Refining Co.*

202. Calcium Cyanamid

Technical data on calcium cyanamid as a source of nitrogen in steel. Applications nitrogen-bearing steels. Effects of nitrogen content. Bibliography. *American Cyanamid Co.*

203. Carburizing

Interesting Char booklet tells how active particles of Char are coated with a heavy layer of carbon, adding to mechanical strength providing a protective coating. *Char Prod. Co.*

204. Castings, Nonferrous

16-page anniversary book, "The Laying Vol. 6, No. 3, furnishes an interesting picture of 50 years of outstanding contribution to the nonferrous metal industry. Also gives a lot of information on nonferrous casting alloys, helpful notes on foundry practice. *R. Lavi Sont, Inc.*

205. Cleaning Brushes

New booklet shows complete line of brushes and actual case histories of how they provide thorough cleaning of red-hot castings in 30 seconds. *Pittsburgh Plate Glass Co., Brush Div.*

206. Coatings, Metal

Explanations of high-vacuum evaporator metals and other solids set forth in detail in new 12-page booklet, "Vaporized Metal-Coat by High Vacuum". *Distillation Products, Inc.*

207. Control Devices

64-page catalog 8303 illustrates over 100 different industrial control devices for temperature, flow, pressure, liquid level, and humidity. *St. Louis Honeywell Div., Brown Instrument*



THINSTEEL KICKS OUT MR. O. V. (Profit Thief)

You can "give the boot" to Oversize Variation in strip thickness, not uncommon in ordinary strip steel, by specifying and using Thinsteel. When deliveries of this precision cold-rolled strip steel are possible under today's conditions, it assures you of maximum yield per ton, particularly important now when every ton of steel must be stretched as far as possible—"kicks out" for good the hidden profit robber, Mr. O. V.

CMP Thinsteel in low carbon, high carbon (annealed or tempered) and stainless grades, offers uniformity in all physicals too, in coil after coil—reduces shut downs, increases die life and units of production for each hour of machine time expended.

Now, CMP is actively engaged in expanding Thinsteel production. New Mills and other additional producing facilities are planned and there is more to come.



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RESULTS

Operation: Threading male pipe union sections on large automatics using single point tools.

Material: Type 310 stainless steel.

Oil:	Previous Oil	Stuart's THREDKUT 9901
Tool Life:	136 pcs. per tool grind	310 pcs. per tool grind
Part Finish:	Fair	Excellent
Cutting Fluid Costs on Machine:	\$9.47 per gal.	\$0.44 per gal.

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Metal Progress: Page 328

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207. Control Devices

64-page catalog 8103 illustrates over 100 different industrial control devices for temperature, flow, pressure, liquid level, and humidity. Minneapolis Honeywell Div., Brown Instrument Co.

WHAT'S NEW IN MANUFACTURERS' LITERATURE

208. Combustion Chambers, Graphite

M-9602 describes the graphite combustion chambers and "Karlate" impervious graphite burner nozzles. Outlines operation of the complete system and points out the principal features, such as long life, absence of corrosion, minimum maintenance, ability to withstand thermal shock, simplicity and moderate installed first cost. National Carbon Co.

209. Copper Alloys

28-page booklet entitled "Copper and Copper Alloys Specifications Index". Section 1 lists most generally used alloys with all applicable specifications. Section 2 lists specifications in numerical order with brief description of materials covered. American Brass Co.

210. Cutting Oils

Write for the pamphlet, "New Improved Gulf L.S. Cutting Base", which describes how production can be speeded up with lower costs and better finishes, using this newly developed cutting oil. Gulf Oil Corp.

211. Electrodes

Approximate carrying capacity of graphite electrodes is shown in this data sheet, which includes chart comparing carbon and graphite capacity. International Graphite & Electrode Co.

212. Electrodes, Welding

New catalog presents complete line of shielded-electrode electrodes for welding of mild steels and alloy steels; includes specifications, mechanical properties and applications. McKay Co.

213. Fatigue Testing

New bulletin describing SF-10-U machine, for vibration testing under conditions of simulated service, with constant-load regulation during test. Baldwin Locomotive Wks.

214. Finishes

Full information and samples on Iridite Al-Coat finishes for aluminum surfaces. Allied Research Products.

215. Furnace, Batch Type

New 4-page illustrated folder discusses the completely automatic cycle of the batch-type furnace. Drawings covering the cycle, and suggestions on how to fit it into production lines, are included. New features also described: radiant heating with temperature build-up; vestibule flushing for clean, scale-free parts; compact size—no pit needed; long tray life; controlled quench temperature and agitation. Holcroft & Co.

216. Furnaces

High temperature furnaces for temperatures up to 2000° F. are described in leaflet. Carl-Mayer Corp.

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217. Furnaces

New all-purpose furnace described in bulletin HD-646 may be used for carburizing, nitriding, dry cyaniding, bright annealing and clean hardening. *Hesi Duty Electric Co.*

218. Furnaces

Catalogs available on complete furnace processes for hardening, tempering, normalizing, carburizing, steam-treatment and dry cyaniding. *Leeds & Northrup.*

219. Furnaces, Atmosphere

Attractive new bulletin describing pit-type controlled atmosphere furnaces for gas carburizing, homogeneous carburizing, dry cyaniding, clean hardening and bright annealing. *Surface Combustion Corp.*

220. Furnaces, Industrial

6-page folder describes 18 typical installations of gas-fired, oil-fired and electric furnaces of various types, complete with specially designed equipment for bright annealing, scale-free hardening, carbon restoration, carburizing and production heat treatment. *Electric Furnace Co.*

221. Furnaces, Reciprocating

Bulletin R15-AB completely describes versatile continuous reciprocating furnaces with positive atmosphere control for economical production heat treating. *American Gas Furnace Co.*

222. Gauges

32-page bulletin on series 500 line of recording gauges. Information is given on pressure gauges for ranges from 0 to 2 inches of water to 0 to 10,000 pounds per square inch, vacuum gauges, low-range draft and pressure gauges, barometers and absolute pressure gauges. *Bristol Co.*

223. Hardness Testers

Bulletin DH-114 contains full information on Tukon hardness testers for use in research and industrial testing of metallic and nonmetallic materials. Also included is bulletin DH-7, giving experiences in various fields. *Wilson Mechanical Instrument Co.*

224. Heat Treating

Pressed steel lightweight sheet alloy heat treating units furnished in any size, design or specification. Write for full information on this. *The Pressed Steel Co.*

225. Heat Treating

New bulletin T-205 lists 118 patterns available in round and rectangular heat treating pots. X-rayed and pressure tested, for sound and economical service. *Electro-Alloys Div.*

226. Heat Treating

Barrett standard anhydrous ammonia is available in 150, 100 and 50-pound cylinders in conveniently located stock points. Send for literature. *Barrett Div., Allied Chemical & Dye Works.*

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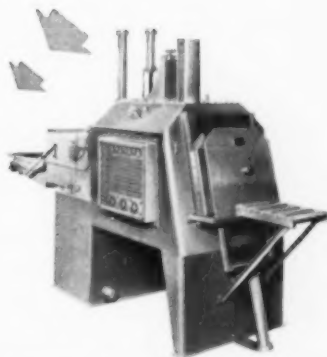
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WHAT'S NEW IN MANUFACTURERS' LITERATURE

227. Heat Treating

Bulletin 123 describes how production is doubled, surface protection improved, and life of tools increased through the use of Ajax salt bath heat treating equipment. *Ajax Electric Co.*

228. Induction Heating

For more economical manufacture in designing and redesigning present products, send for copy of "Design and Manufacture for Profit" with full details on Tocco Induction Heating for brazing, hardening, soldering, forging or shrink fitting. *Ohio Crankshaft Co.*

229. Induction Heating

New bulletin 14-A tells how to master heat treating problems with a combination of melting speed, superfine control, and over all economy provided by the Ajax Northrup 20 kw converter-operated induction furnace. *Ajax Electrothermic Corp.*

230. Laboratory Equipment

Full details available on RSL Spec-Power newly developed control cabinet featuring air interrupter for quick adjustment of voltage, a SKVA AC spark providing increased stability and precision and redesigned unit for cutting down floor space. *National Spectrographic Labs.*

231. Mercury Cathode

Bulletin 220-1 describes completely new magnetic mercury cathode Dyna-Cath and shows how it permits economical and high speed separation of iron in determination of aluminum in steel. Also Methods Manual 260-1. *Eberbach & Son Co.*

232. Metal Cleaner

Information on all drawing and cleaning problems, using Fluid Film U-19 and metal cleaner No. 78 for rapid and economical cleaning of metal parts prior to plating, soldering, painting or vitreous enameling. *Northwest Chemical Co.*

233. Metal Cutting

New 64-page catalog gives prices and describes complete line of rotary files, hurs, metal-working saws and other products. *Martindale Electric Co.*

234. Metal-forming Lubrication

New bulletin 426-10C describes how colloidal graphite can solve your lubrication problems in metal-forming operations at temperatures from below zero up to 5000° F. *Acheson Colloids Corp.*

235. Metal Spinning

New Spincraft data book—a valuable reference bulletin that illustrates lower costs made possible through pioneering developments in working of metals. *Spincraft, Inc.*

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METAL PROGRESS

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March, 1951

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181	199	217	235	253
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236. Metal Stripper

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243. Plating and Finishing

New catalog of "Buffing & Polishing Compositions" contains wealth of valuable information on finishing. Illustrated with charts showing compositions to use on all types of metal from aluminum to zinc. *Laslon, Inc.*

244. Potentiometers

Dynalog instruments for control of temperature, humidity, pressure, flow, etc. Details in bulletin 427. *Foxboro Co.*

245. Press Forging

Bulletin 75-B explains how many parts can be press forged better, faster and at less cost than by any other method. *Ajax Mfg. Co.*

246. Pyrometer

Catalog 80 illustrates and describes the Pyro Optical Pyrometer for quick, accurate temperature readings on minute spots, fast-moving objects and small streams in a temperature range from 1400° F. to 7500° F. *Pyrometer Instrument Co.*

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248. Radiography

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249. Reclaiming Process

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252. Specimen Cutter

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255. Steel Bar Stock

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256. Steel Forgings

For complete line of forgings at lower cost write for catalog, "Timken Steel Products". *Timken Roller Bearing Co.*

257. Steel, Cold Finished

16-page bulletin entitled "You Can Make Them Better with Cold Finished Jalcase" gives technical information charts and grades about Jalcase 10 and nine other grades of this fine carbon steel. *Jones & Laughlin Steel Corp.*

258. Steel Sorting

Descriptive literature available on Fisher Steel Sorter for separating mixed lots of steel quickly and non-destructively. *Fisher Scientific Co.*

259. Steel, Stainless

New bulletin describing analysis of new stainless steel that offers superior corrosion resistance to hot solutions of sulphuric acid. Available in bar, wire, strip and forging billets, also tubing pipe, sheet and plate. *Carpenter Steel Co.*

260. Steels, Alloy

Booklet on Carilloy steels tells how No. 4150 and others provide toughness, strength, and light weight durability under trying conditions of service. *U. S. Steel Co.*

261. Steel, Brake Die

For full information on top quality brake die steel, engineered to machine easily and give long service, write for folder 560. *Bethlehem Steel Co.*

262. Tubing

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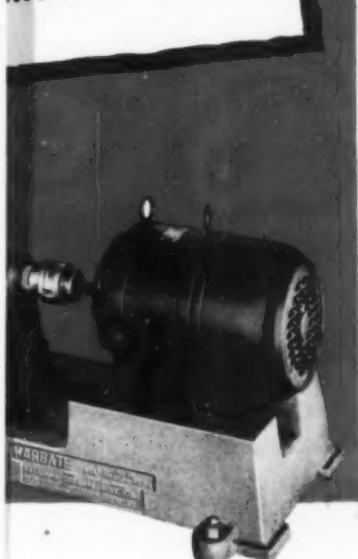
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265. Welding Electrodes

24-page reference and instruction book W-17 includes technical information about all bronze electrodes along with recommended techniques for welding and machining. *Amperco Metal, Inc.*

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CINDER NOTCH PLUGS • SKIMMER
MOLD PLUGS • TANK HEATERS

March, 1951; Page 329

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WHAT'S NEW

IN MANUFACTURERS' LITERATURE

227. Heat Treating

Bulletin 123 describes how production is doubled, surface protection improved, and life of tools increased through the use of Ajax salt bath heat treating equipment. *Ajax Electric Co.*

228. Induction Heating

For more economical manufacture in designing and redesigning present products, send for copy of "Design and Manufacture for Profit" with full details on Tocco Induction Heating for brazing, hardening, soldering, forging or shrink-fitting. *Ohio Crankshaft Co.*

229. Induction Heating

New bulletin 14-A tells how to master heat treating problems with a combination of melting speed, superline control, and overall economy provided by the Ajax-Northrup 30 kw converter-operated induction furnace. *Ajax Electrothermic Corp.*

230. Laboratory Equipment

Full details available on NSL Spec-Power newly developed control cabinet featuring air interrupter for quick adjustment of voltage, a 5KVA AC spark providing increased stability and precision and redesigned unit for cutting down floor space. *National Spectrographic Labs.*

231. Mercury Cathode

Bulletin 220-1 describes completely new magnetic mercury cathode Dyna-Cath and shows how it permits economical and high speed separation of iron in determination of aluminum in steel. Also Methods Manual 260-1. *Eberbach & Son Co.*

232. Metal Cleaner

Information on all drawing and cleaning problems, using Fluid-Film U-19 and metal cleaner No. 78 for rapid and economical cleaning of metal parts prior to plating, bonding, painting or vitreous enameling. *Northwest Chemical Co.*

233. Metal Cutting

New 64-page catalog gives prices and describes complete line of rotary files, bars, metal working saws and other products. *Martindale Electric Co.*

234. Metal-forming Lubrication

New bulletin 426-10C describes how colloidal graphite can solve your lubrication problems in metal-forming operations at temperatures from below zero up to 3000° F. *Acheson Colloids Corp.*

235. Metal Spinning

New Spincraft data book—a valuable reference bulletin that illustrates lower costs made possible through pioneering developments in working of metals. *Spincraft, Inc.*

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METAL PROGRESS

7301 Euclid Avenue, Cleveland 3, Ohio

March, 1951

180	198	216	234	252
181	199	217	235	253
182	200	218	236	254
183	201	219	237	255
184	202	220	238	256
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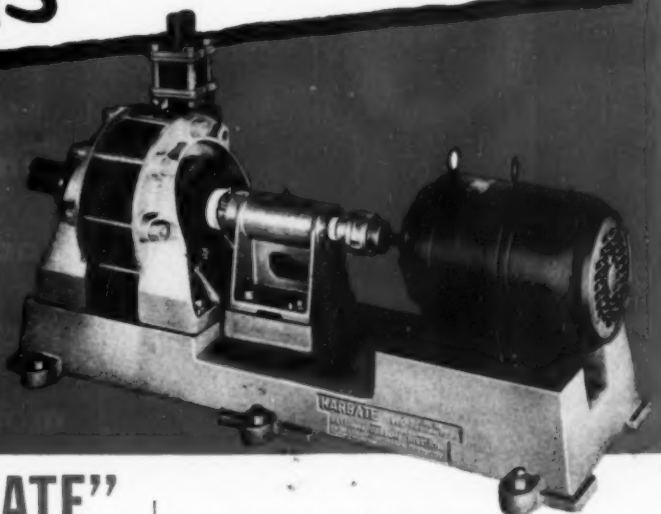
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NOW SAVE 2 WAYS

not only by—**REDUCED PRICES**
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LOWER MAINTENANCE COST

To the savings made by the reduction in "Karbate" brand impervious graphite pump prices (up to 33%), add the all-important factor of very low annual maintenance cost. Our records show some pumps in service for years, requiring practically no replacement parts.



Specify **"KARBATE"**
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**Impervious Graphite
Corrosion Resistant**

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HERE'S WHY—

- Case and Impeller are of "Karbate" impervious graphite — they do not corrode.
- Stainless Steel Shaft, where exposed to corrosive fluids, protected by "Karbate" impervious graphite.
- "Karbate" impervious graphite rotary seals* are regular equipment — included in basic pump price. They are not "extras".
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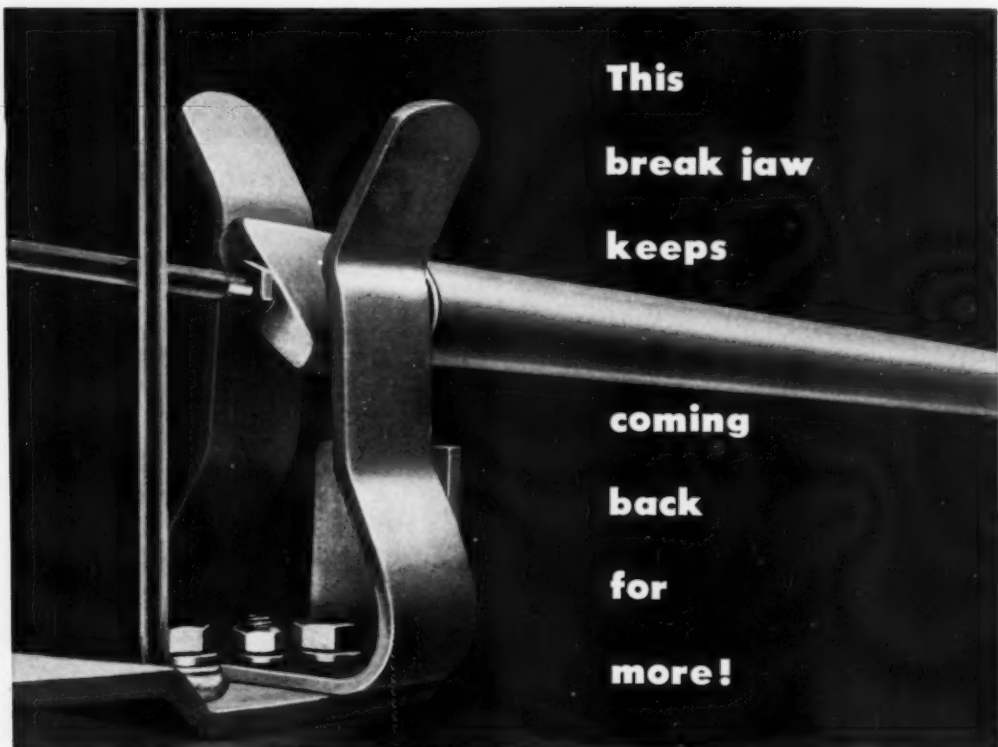
- All-purpose application
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**BLAST FURNACE LININGS • BRICK • CINDER NOTCH LINERS • CINDER NOTCH PLUGS • SKIMMER
BLOCKS • SPLASH PLATES • RUNOUT TROUGH LINERS • MOLD PLUGS • TANK HEATERS**



**This
break jaw
keeps

coming
back
for
more!**

IT'S MADE OF **BERYLCO** BERYLLIUM COPPER

The break jaw shown here is an integral part of the Westinghouse V type disconnecting switch, designed for outdoor operation at 7½ to 230 KV, 400 to 2,000 amp. Why is it made of Berylco Beryllium Copper?

Because Westinghouse engineers wanted these qualities: good electrical conductivity; bulldog ability to grip the moving contact tightly, without relaxation, over a wide current range for long periods of time; enough "bounce" to withstand above-normal deflection without taking a permanent set.

Of all current-carrying materials, only Berylco 10 could meet these exacting demands.

Furthermore, Berylco's unique combination of high conductivity and high elasticity made it possible to design the break jaw in one piece. Construction was thus simplified, efficiency of operation improved.

Good electrical conductivity, high strength, excellent fatigue resistance are only a few of the properties of this versatile alloy. Perhaps Berylco can help improve the quality of your product or lower your costs. Take advantage of the technical knowledge of the world's largest producer of beryllium copper. Blueprint your problem...or send for sample material.

BERYLCO IS AVAILABLE as casting alloy in ingot form, rounds, rectangles, hexagons or squares, wire and strip.

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Unexcelled
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Quenching
Operations...



Park Nu-Sal and Thermo-Quench

NU-SAL AND THERMO-QUENCH ... two Park laboratory controlled heat-treating salts that make an unbeatable team on interrupted quenching operations!

Nu-Sal, you know, possesses unusually high thermal-conductivity. It provides rapid, uniform heating that assures consistently good results and its working range covers the hardening temperatures of most commonly used steels. In addition, you'll find that Park Nu-Sal forms an exceptionally fluid austenitizing bath of great fluidity and miscibility.

Thermo-Quench is a more recent Park development made especially for interrupted quenching, transformation and tempering operations. It has a low melting point 290° F. ... and it forms an extremely fluid bath that provides desirable cooling rates through the critical zone.

For specific application recommendations on these and other Park laboratory controlled heat-treating products, consult your nearest Park Service Representative or send us full particulars direct.

New NEUTRA-GAS PROCESS* FOR MAINTAINING NEUTRALITY OF CHLORIDE-BASE SALT BATHS!

• Latest development of Park's research laboratories is the new Neutra-Gas Process ... a simple, efficient, economical method of maintaining absolute neutrality in chloride-base salt baths. Suitable for use between 1350° and 1950° F., the new Process completely eliminates objectionable oxides simply by periodically passing small amounts of harmless gas through the molten salt.

No rectifiers are required ... sludging is eliminated ... and no fresh salt additions are needed except to replace drag-out. Further, the Process maintains original fluidity of the bath and work leaves as clean as when it entered. Write today for our Technical Bulletin No. H-25. It tells the whole story.



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2,474,680

For a full 3000F

JM-3000

For use to 2800F

JM-28

For use to 2600F

JM-26

For use to 2300F

JM-23

For use to 2000F

For use to 1600F exposed
For use to 2000F as backup

these 6 types of
Johns-Manville
Insulating Fire Brick
are designed to
bring you important
fuel savings

You can make important savings in fuel by taking advantage of the quick heating characteristics of J-M Insulating Fire Brick. These light-weight brick permit a quicker rise to proper operating temperature in the furnace because of their low heat storage capacity, and low thermal conductivity. Where furnaces are being intermittently operated these are two especially important characteristics.

These same insulating materials can also be obtained in large size units called Johns-Manville Insulating Fireblok. This product has many advantages over the smaller size fire brick for certain types of jobs . . . from both a construction and stability standpoint. The Fireblok units can be quickly applied because they are easy to cut and fit. Fireblok insulations provide additional heat savings be-

cause they reduce the number of joints, and require less mortar for bonding.

It will pay you to let a Johns-Manville insulation engineer explain the many ways in which you can save by using these insulations in your furnaces. Just write for further information to Johns-Manville, Box 290, New York 16, N. Y.



	JM-1630	JM-20	JM-23	JM-26	JM-28	JM-3000
Densities, lb per cu ft.....	29	35	42	48	58	63-67
Transverse Strengths, psi.....	60	80	120	125	120	200
Cold Crushing Strengths, psi.....	70	115	170	190	150	400
Linear Shrinkage ¹ , percent.....	0.0 at 2000 F	0.0 at 2000 F	0.3 at 2300 F	1.0 at 2600 F	4.0 at 2800 F	0.8 at 3000 F
Reversible Thermal Expansion, percent.....	0.5-0.6 at 2000 F	0.5-0.6 at 2000 F	0.5-0.6 at 2300 F	0.5-0.6 at 2600 F	0.5-0.6 at 2800 F	0.5-0.6 at 3000 F
Conductivity ² at Mean Temperatures						
300 F.....	0.77	0.97	1.51	1.92	2.00	3.10
1000 F.....	1.02	1.22	1.91	2.72	2.50	3.20
1500 F.....	1.37	1.47	2.31	3.52	3.00	3.35
2000 F.....	—	1.72	2.70	2.82	3.50	3.60
Recommended Service						
Back up.....	2000 F	2000 F	2300 F	2600 F	2800 F	3000 F
Exposed.....	1600 F	2000 F	2300 F	2600 F	2800 F	3000 F

¹24-hr. simulative service panel test for JM-3000, 24-hr. soaking period for other brick.

²Conductivity is expressed in Btu in. per sq ft per F per hour of the designated mean temperatures.

Note: Above tests are in accordance with A.S.T.M. tentative standards.

Johns-Manville *first in* **INSULATIONS**

MAKE A TON OF SHEET STEEL
GO FARTHER

Specify-



... And
"MAKE YOUR PRODUCT
LAST LONGER"

Now, more than ever before, America must make full use of its steel-making capacity and conserve its natural resources. Now, more than ever, there is national significance in the phrases, "Make a ton of sheet steel go farther" and "Make your product last longer."

These low-alloy, high-tensile steels do "make a ton of sheet steel go farther"—for their inherently higher strength is 50% greater than mild carbon steel. That means, in turn, that 25% less section can be used with safety, and where rigidity is important, this can usually be

compensated for through slight design change.

"Make your product last longer" is no idle claim. The much greater resistance of N-A-X HIGH-TENSILE to corrosion, abrasion, and fatigue assures longer lasting products even at reduced thickness.

Explore the potential economies to be derived from the use of low-alloy, high-strength steels—and then specify them. Their use can add materially to our national conservation program.

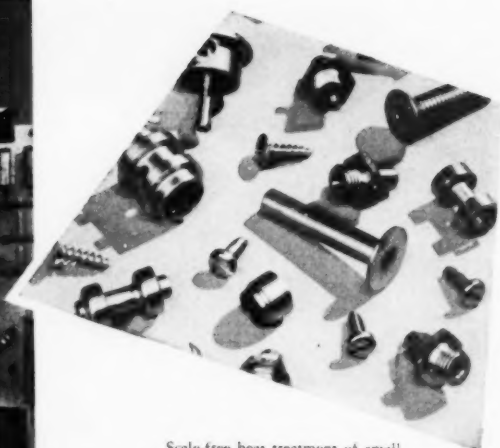
GREAT LAKES STEEL CORPORATION

N-A-X Alloy Division, Ecorse, Detroit 29, Michigan

NATIONAL STEEL



CORPORATION



Scale-free heat treatment of small parts in Ferrotherm furnaces depends on gas tight Inconel muffles.

A Ferrotherm furnace, equipped with Inconel muffle, used for bright annealing and hardening of stainless steels and air hardening tool steels.

INCONEL MUFFLES OUTLAST OTHERS 12 TO 1 IN FERROTHERM CO. ATMOSPHERE FURNACES

The Ferrotherm Company of Cleveland, Ohio, and Pittsburgh, Pa., has developed and built a number of unique furnaces for the special treatment of metals. Among the processes carried out in these furnaces are:

- Bright hardening of hardenable stainless steels and air hardening tool steels.
- Furnace brazing of stainless steel and other alloys.
- Bright annealing of stainless steel, tool steel and other alloys.
- Custom treatments, such as solution and precipitation of various alloys including "Duranickel", "K" Monel, Beryllium Nickel, Beryllium Copper, as well as electrical and magnetic steels.

The atmospheres used for these treatments are anhydrous dissociated ammonia, or pure, dry hydrogen. It is imperative to the success of these treatments that the purity and dryness of furnace atmospheres be maintained throughout the heating cycle. This means, of course, that furnace muffles must be dependably sound and tight at all times.

Mr. John R. Gier, President of the Ferrotherm Company, has this to say about his concern's experience with furnace muffles:

"The engineering requirements for a metal to be used in our furnace muffles are very severe. Chief among them are:

- A) Good resistance to cracking caused by the extreme thermal variations inherent in batch type operation.

- B) Good resistance to oxidation at temperatures up to 2100° F.

- C) Good fabricating qualities; especially good welding characteristics because joints must be tight and gas-leak proof.

"We tested a number of different materials for this application, and Inconel® proved to be the best of all. The fact that we have been using Inconel exclusively for our muffles for the last ten years is the strongest indication I can give of our satisfaction with Inconel on all counts.

"In our around-the-clock, five-to-seven day a week type of operation, we have come to expect our Inconel muffles to give a minimum of twelve months service. The best service we have experienced with other metals tried was about one month."

Because current government demands draw so heavily on the available supply of nickel and its alloys, you may not be able to buy all the Inconel you need right now. However, we will continue to report interesting service stories and developments, in the hope that they will be of value to you in the future.

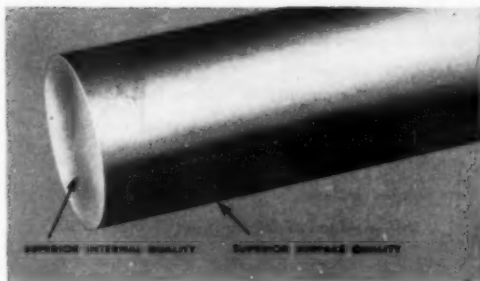
And, of course, you are always welcome to bring your high-temperature metal problems to INCO's Technical Service Section. Write them, outlining your problem. They may be able to suggest a solution.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.



INCONEL ... for long life at high temperatures

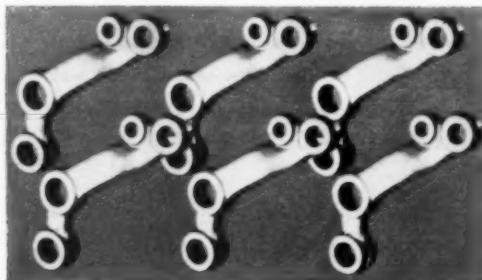
3 ways TIMKEN® steels help you make better forgings —at lower cost!



1 HIGH QUALITY! The superior surface and internal quality of Timken® forging steels, plus their uniform forgeability, gives you better finished forgings—with fewer rejects, delays and shop-practice changes.



2 TAILOR-MADE! Using advanced melting and finishing techniques, Timken makes certain that chemical and physical properties will meet your specifications exactly.



3 UNIFORM! From bar to bar and from heat to heat, Timken forging steels give you uniform composition, uniform forgeability and uniform response to heat treatment. That's assured by Timken's rigid control and inspection methods.

For better forgings at lower cost, get the recommendations of our Technical Staff. And for a complete catalogue of our steels, "Timken Steel Products", write on your letterhead to The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

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Specialists in alloy steel—including hot rolled and cold finished alloy steel bars—a complete range of stainless, graphite and standard tool analyses—and alloy and stainless seamless steel tubing

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Metal Progress; Page 338

TEN

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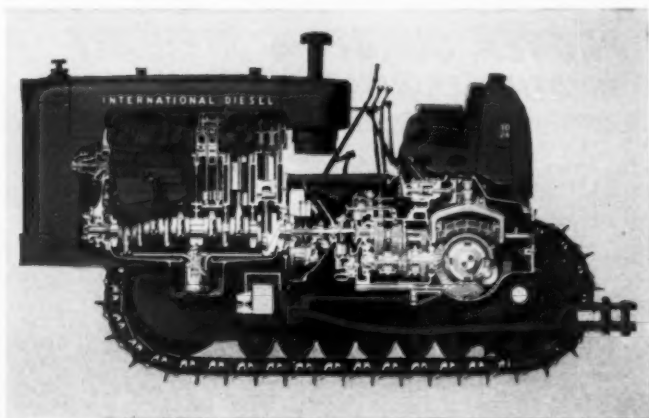


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WISCONSIN STEEL

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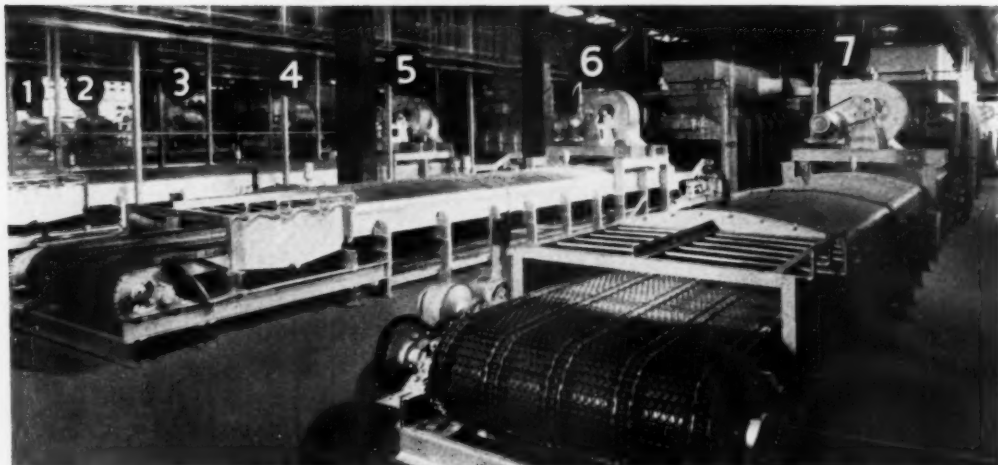
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1. Shells automatically travel through alloy tubes while heating. Chain conveyor design also available.



2. Shells discharging into quench cages within tank for external and internal quenching. (Photo taken without oil in tank shows mechanism.)



3. Shells being carried upward from quench tanks and discharged onto the conveyor belts of the draw furnace.



4. Shells discharging from the draw into the conveyor belt of the cooling chamber.



5. Shells emerging from the cooling chamber after their completely automatic processing.

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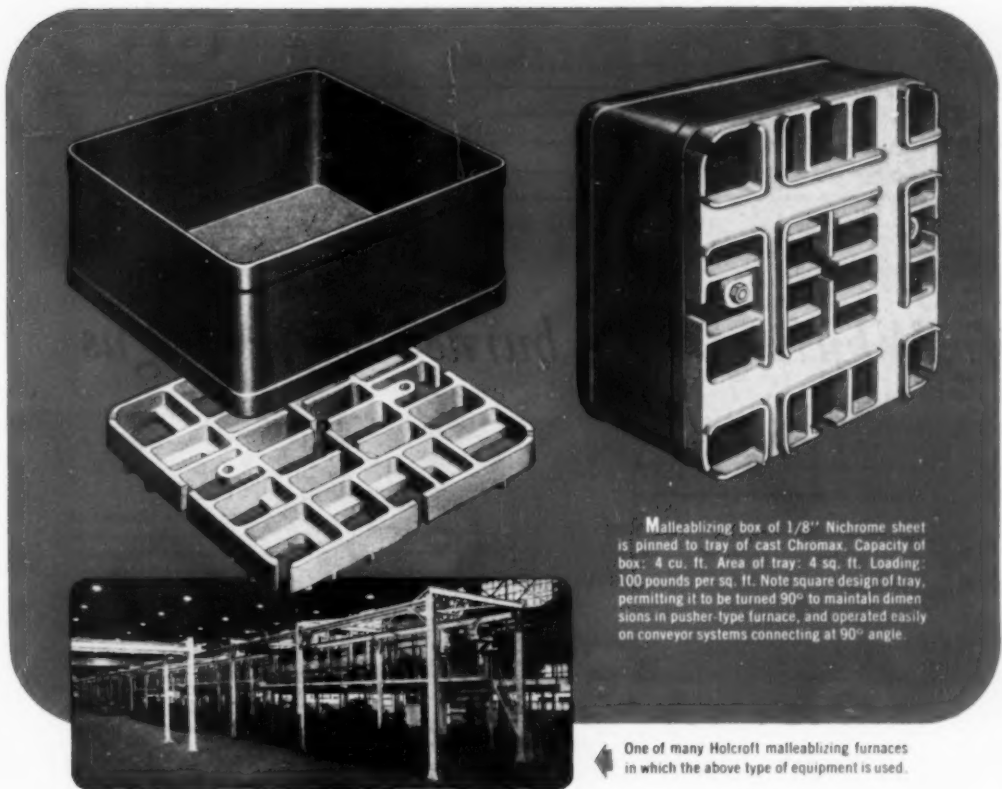
MACHINE GUN CLIPS (Harden, Quench and Draw).

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A letter, wire or phone call will promptly bring you information and details on SUNBEAM STEWART furnaces, either units for which plans are now ready or units especially designed to meet your needs. Or, if you prefer, a SUNBEAM STEWART engineer will be glad to call and discuss your heat treating problems with you.



Malleablizing box of 1/8" Nichrome sheet is pinned to tray of cast Chromax. Capacity of box: 4 cu. ft. Area of tray: 4 sq. ft. Loading: 100 pounds per sq. ft. Note square design of tray, permitting it to be turned 90° to maintain dimensions in pusher-type furnace, and operated easily on conveyor systems connecting at 90° angle.

One of many Holcroft malleablizing furnaces in which the above type of equipment is used.

How Live Load Ratio was improved 250%

A large midwestern implement foundry has proved that use of trays and boxes made of Driver-Harris alloys, for malleable annealing of small parts, results in outstanding savings in deadweight and better heat transfer. Production has been stepped up considerably by increasing live load and shortening the heat-treating cycle.

Hard cast iron boxes, formerly used in tunnel kilns, weighed 650 pounds each, and carried a maximum work load of 330 pounds—giving a load ratio of approximately 0.5 to 1.

Boxes in service today are fabricated from 1/8" Nichrome® sheet. These are pinned to specially designed trays of cast Chromax® (see illustration). Box load is 400 pounds. Total weight of a box and tray is 180 pounds. Thus load ratio is 400 to 180, or approximately 2 1/4 to 1.

Such a remarkable improvement in the ratio of live load to deadweight of containers (almost 250%) has, of course, resulted in proportionate improvement in efficiency—or fuel saving.

To date, these boxes and trays have given 36 months of service in a continuous malleablizing furnace. During this period, they have made 480 trips through the furnace—representing 480 heat and cool cycles. They have been in the furnace 22,640 hours, about 86% of the total elapsed time, under temperatures up to 1725°F. Each box has annealed 90 tons of work.

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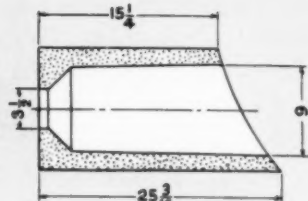
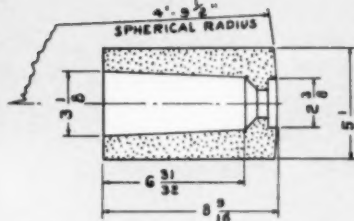
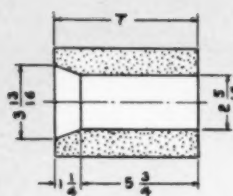
Here is but another example of how Driver-Harris alloys are being applied to great advantage in the heat-treating field. Why not consult with us for a solution to *your* heat-treating equipment and furnace part problems? Although the demand for D-H products in the present emergency is engaging the resources of this firm to an unprecedented extent, we shall be glad to serve you to the best of our ability.



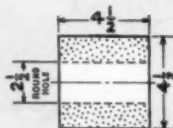
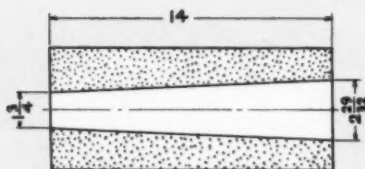
Nichrome and Chromax are manufactured only by
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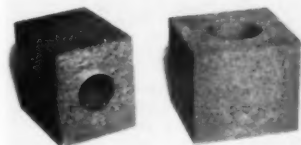
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For more complete information about Norton burner blocks, consult your nearby Norton representative, or write direct for Bulletin R-1N. NORTON COMPANY, 323 New Bond St., Worcester 6, Mass.

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March, 1951

Volume 59, No. 3

Metal Progress

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Cover by Edward A. Gue

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INLAND DATA for STEEL USERS INLAND STEEL CO.

38 S. Dearborn Street, Chicago 3, Illinois

*Typical mill tests
for quality control
of your steels*

An important aspect of steel manufacturing is that, in the great majority of cases, steel is "tailor-made" to meet a specification or to make a particular part. It is therefore necessary for the steelmaker to know as much about each heat of steel as can be efficiently obtained. The tests described below are the main tests run by the steel producer to check the quality of the steel

against the specified requirements. Naturally these tests do not stand alone as the final quality determinants. The steelmaker uses many other tests and his metallurgical experience as well as his knowledge of the steel fabricating processes to assure the customer of the right steel for the job.



BEND TEST

Bend tests are employed to determine the ability of steel to withstand cracking during subsequent forming operations at the customer's plant. Basically, the test consists of bending test pieces through certain specified arcs. (photos 1 and 2). The amount of bending a piece of steel will withstand depends on its chemical composition, its tensile strength, its thickness, and its grain structure.



HARDNESS TEST

Abrasion, indentation, wear, cutting and shearing . . . all these are related to the hardness factor of the steel. Hardness tests are most often made after the steel has been heat-treated or just before it is to be temper rolled. Hardness is measured by Rockwell or Brinell testing machines (photo 3) which indent the surface of the specimen with a predetermined load. The

relationship of the load and depth of indentation is then translated into a hardness reading.

CUPPING TEST

Clues to a steel's suitability for future drawing operations are uncovered by the cupping test. In this test, a sample piece of steel is placed in a special machine in which a smooth metal ball is forced against the flat surface of the specimen thus drawing it into the form of a cup and continuing the



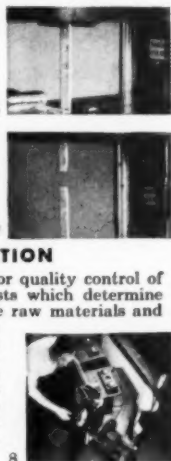
distortion until the material is fractured (photos 4 and 5).

TENSION TEST

In applications where the steel will be under stress, either static or dynamic, the steel mill quality control department is interested in determining certain mechanical properties of the steel . . . tensile strength, yield point and the amount of elongation in a specimen of a certain length. Specimens of the various products are pulled asunder until fractured by hydraulic or mechanical testing machines which accurately measure the applied load (photos 6 and 7).

CHEMICAL DETERMINATION

The most widely used tests for quality control of steel at the mill, are the tests which determine chemical compositions of the raw materials and the finished products. It is estimated that Inland runs 1,250,000 chemical determinations each year. In addition to the wet chemical tests, the spectrographic method (photo 8) is widely employed for making quick, accurate determinations.



By E. C. Wright*
*Head, Department of Metallurgy
University of Alabama*

More Manganese

From American

Ores and Slags

MANGANESE is vital to the production of steel; therefore, any method for extending the supply of this element is of primary importance in this period of international tension. In 1948, the steel industry consumed nearly 1,500,000 net tons of manganese ore containing 590,000 tons of manganese. The current problem is to determine what must be done to assure manganese supplies for even higher rates of production. The simplest answer would be to obtain a suitable stockpile of proper ores for standard ferromanganese production in time of emergency. Although such a stockpile is being accumulated, we should be prepared for the time when this procedure breaks down or the stockpile is inadequate.

The critical importance of manganese relates to its effect in combatting the deleterious effects of sulphur in steel of all types and grades. During recent years the sulphur content of such basic raw materials as coal, coke, and pig iron has gradually increased and has simultaneously increased the amount of necessary manganese. Openhearth metallurgists are alive to this problem, and only recently the details of sulphur control by manganese have been thoroughly discussed by D. E. Babcock in the 1949 Yearbook of the American Iron and Steel Institute.

In addition to the increase for sulphur control, there has been a tendency to increase the

specified manganese content in a large portion of the steel produced. As a result of these changes, the consumption per ton of ingots has steadily increased from about 11 lb. Mn in 1940 to more than 13.5 lb. in 1948, and the figure is probably even higher at the present time.

Assuming that 14 lb. of manganese will be used in each of the 100,000,000 tons of steel produced in 1950, the total annual manganese requirement now reaches 700,000 net tons. This is nearly equivalent to the yearly production of copper or aluminum and serves to emphasize its tremendous strategic importance.

The principal source of manganese for the steel industry is standard ferromanganese produced from blends of high-grade manganese ores. A little over 90% of the ore is imported, the major sources being Brazil, the Gold Coast, India, and the Union of South Africa. (Russia used to be a prime source of supply.) American ores come almost entirely from Montana; in 1948 this amounted to 9.4% of the total. Intensive investigations have shown that processes aimed at utilizing available low-grade American ores have all proved to be uneconomical.

It has long been recognized that the steel industry throws on the slag dump as much manganese as it uses in the form of ferro-alloys. Typical slags in the various stages of steel manufacture in American plants are shown in Table I; their manganese content runs around 20%—even higher, depending on the type of refining operation employed in finishing the steel. Numerous attempts at reclaiming this manganese by leaching, smelting, or concentration methods, have all been unsuccessful in terms of yield for effort and material necessary.

*The author appreciates the counsel and guidance of A. B. Kinzel, president, C. M. Offenhauer, research metallurgist, and Walter Crafts, chief metallurgist of Union Carbide and Carbon Research Laboratories, Inc. T. C. Ereon assisted in making and treating the experimental heats.

The manganese in the low-silica slags (such as openhearth runoff and final slags) may be recovered by leaching with sulphuric acid and electrolysis of the solution but the consumption of acid in reacting with the iron, lime and magnesia combined with the high power cost for electrolytic recovery of the manganese (6 kw-hr. per lb.) makes this method uneconomical. Smelting with reducing materials reduces all the iron and phosphorus into a low-grade manganese alloy unsuited for finishing operations on heats of steel. On the other hand, the high-silica slags

manganese ores such as those found on the Cuyuna range in Minnesota. Use of such materials would have little effect on transportation costs of the raw material—a factor which has greatly handicapped the use of low-manganese ores, as many of the deposits are far from steel producing centers.

The method of concentrating manganese values proposed in this article (and on which patent has been applied for) depends on the above-mentioned fact that manganese tends to oxidize more readily than other constituents of

Table I—Analyses and Quantities of Steel Mill Slags

	MIXER SLAG	BESSEMER SLAGS		OPENHEARTH SLAGS				
		4 MIN. (a)	LADLE (b)	RUNOFF (c)	RUNOFF (b)	RUNOFF (d)	FINAL	LADLE (e)
MnO	34.10	23.90	24.10	15.10	20.80	16.67	7.17	44.20
(Mn)	26.40	18.51	18.68	11.71	16.10	13.68	5.65	34.30
FeO	10.70	20.24	20.50	44.59	27.00	42.20	15.02	24.60
(Fe)	8.32	15.70	15.90	34.70	21.00	32.80	11.68	19.30
SiO ₂	54.50	53.44	50.30	21.28	24.30	20.14	17.05	12.0
CaO	0.40	0.50	2.45	11.71	14.20	9.50	46.85	12.20
MgO				3.11	5.70	3.30	8.00	1.20
P ₂ O ₅				1.32	3.3	2.25	1.51	
Al ₂ O ₃	0.20			2.20	3.00	2.57		5.10
Lb. slag (f)	50	130	165	160	144	150	150	28
Lb. Mn (f)	13.2	21.4	25.8	18.7	23.2	20.5	8.5	9.5

(a) Based on pig iron with 1.08% Si and 0.80% Mn.

(b) Quoted from Bray, "Ferrous Production Metallurgy".

(c) Based on hot metal with 0.50% Mn; average of several heats.

(d) Quoted from "Basic Openhearth Steelmaking", A.I.M.E.

(e) Deoxidation slag from rimmed steel heat (45% Mn recovery).

(f) Pounds per ton of steel.

from the bessemer converters are insoluble in acid and so low in manganese-iron ratio that they yield a very low-grade manganese alloy when smelted.

Studies of the bessemer process during the last 50 years have established the sequence in which impurities in the pig iron are oxidized; thus, manganese and silicon are oxidized before much of the carbon goes. Unfortunately most of this work has been done with normal bessemer pig irons with less than 0.6% manganese, and the resultant slag is similar to the bessemer ladle slags shown in Table I.

Based on many observations in the literature and on thermochemical data it was deduced that slags quite high in manganese might be obtained by blowing pig irons containing higher manganese (in the range of 1 to 8%). Such pig irons may be readily made by adding to the normal iron ore burden of the blast furnace various amounts of recycled flush or final openhearth slags, bessemer slags, or low-grade man-

ganese ores, such as those found on the Cuyuna range in Minnesota. Use of such materials would have little effect on transportation costs of the raw material—a factor which has greatly handicapped the use of low-manganese ores, as many of the deposits are far from steel producing centers. The method of concentrating manganese values proposed in this article (and on which patent has been applied for) depends on the above-mentioned fact that manganese tends to oxidize more readily than other constituents of the bath with the exception of silicon. These two are almost simultaneously and rapidly eliminated in the first stage of oxidation, while the other constituents remain behind, largely unaltered. By the use of this principle, slags sufficiently high in manganese and of a manganese-iron ratio approximating that in some lower grade foreign ores may be obtained, such as the African ores containing 38 to 40% Mn, 12 to 16% Fe, and 3 to 20% SiO₂, which are now being imported in considerable tonnage for blending purposes.

Experimental Procedure—The early stages of oxidation were studied by melting a number of induction furnace heats of pig iron, oxidizing the charges to various degrees, and collecting samples of slag and metal. The composition was adjusted to different initial contents by adding manganese and silicon metal to a molten pig iron. Temperatures were determined by platinum thermocouples, and the melts were oxidized by high-purity oxygen introduced through an iron or silica tube. (High-purity oxygen was used because it was convenient, but it is believed that proportionate oxidation by

air or other oxygen source would produce similar results.) Oxygen consumption was measured by a medical oxygen rotameter; the rate of flow was generally about 6 l. per min. The power input into the furnace was reduced during the blowing period to compensate for the heat produced by oxidation. At the end of the blowing period, the bath temperature was remeasured, and samples of slag and metal were obtained. The slag appeared to change from a rather refractory and viscous mass to a thin, fluid liquid as the oxidation proceeded. The fluid slag was removed as completely as possible by freezing it on an iron rod; by this means the variations in slag composition caused by reaction with the colder crucible walls were minimized. (There was little attack on the silica crucibles. Some of them were reused without severe cutting at the slag line.)

Results—Chemical analyses of the metal, before and after oxidation, and of the slags produced in representative heats, are listed in Table II. It is apparent that the manganese

oxide content of the slag is dependent on the manganese content of the metal bath at the time the slag was removed.

Note the following figures:

HEAT No.	MN IN BLOWN METAL	MN IN SLAG
5-392	0.11	21.65
5-389	0.35	21.91
5-393	0.41	44.13
5-652	0.55	37.43
5-651	0.69	45.03
5-391	0.70	47.88
5-390	0.77	49.76

The more important relation between residual manganese in metal and the ratio of manganese oxide to iron oxide in the slag is shown graphically in Fig. 1, wherein connected points represent successive samples taken at intervals during the oxidation of one melt, and isolated points represent the end of other heats. It is apparent that slags containing more than four times as much MnO as FeO were obtained from the melts in which oxidation stopped before the manganese dropped below 0.8% in the metal. Below this

Table II—Data on Experimental Heats

HEAT No.	INITIAL IRON ANALYSIS			LITERS BLOWN O ₂	TEMP., °C. (c)	ANALYSIS OF IRON AFTER BLOWING			ANALYSIS OF SLAG (f)			MnO/FeO RA ^(g)
	% C	% Mn	% Si			% C	% Mn	% Si	% MnO	% FeO	% SiO ₂ (g)	
5-389 (Note a)	4.40	0.98	1.00	25	1439	4.17	0.75	0.66	20.67	34.63	42.48	0.60
	4.17	0.75	0.66	25	1452	4.06	0.52	0.47	23.85	30.61	44.28	0.78
	4.06	0.52	0.47	25	1462	3.98	0.32	0.32	19.97	38.37	39.72	0.52
	3.98	0.32	0.32	10	1529	4.63	0.35	0.25	21.91	31.63	46.60	0.69
5-390 (Note a)	4.40	4.00	1.00	25	1424	4.00	3.79	0.87	51.95	7.47	40.24	6.95
	4.00	3.79	0.87	37.5	1462	3.96	2.84	0.61	52.89	6.18	41.00	8.56
	3.96	2.84	0.61	30	1474	3.91	2.34	0.42	52.65	7.33	40.64	7.18
	3.91	2.34	0.42	36	1507	3.83	1.55	0.28	52.20	7.62	39.92	6.85
	3.83	1.55	0.28	30	1525	3.77	0.77	0.09	49.76	10.63	39.12	4.68
	4.40	4.36	1.00	20	1473	3.80	3.41	0.74	53.40	9.34 (e)	37.50	5.72
5-391 (Note b)	3.80	3.41	0.74		1504							
	3.80	3.41	0.74	25.5	1518	3.57	2.76	0.42	52.67	10.92	36.00	4.82
	3.57	2.76	0.42	30	1534	3.42	2.06	0.59	53.81	9.77	37.20	5.51
	3.42	2.06	0.59	25	1548	3.30	1.52	0.26	53.52	8.62	39.00	6.21
	3.30	1.52	0.26	30	1546				54.49	6.90	40.40	7.90
5-392 (b)				23.5	1568	2.85	0.70	0.12	47.88	9.48	43.88	5.05
5-393 (b)	3.77	3.06	0.76	240	1362	1.94 (b)	0.11 (d)	0.01	21.65	47.13	26.60	0.46 (d)
5-652 (b)	3.98	3.04	0.80	108	1398	2.41 (b)	0.41 (d)	0.07	44.13	21.99	33.36	2.01 (d)
5-651 (b)	4.17	1.48	0.86	126	1629	3.43 (b)	0.55 (d)	0.20	37.43	17.54	43.26	2.13 (d)
5-651 (b)	3.94	3.23	0.89	120	1628	3.33 (b)	0.69 (d)	0.18	45.03	12.36	40.98	3.64 (d)

(a) Silica tube used for blowing oxygen; this dissolved, increasing SiO₂ content of slag.

(b) Iron pipe used for blowing oxygen; this dissolved rapidly and was oxidized to FeO by the oxygen passing through the hot tube immersed in the bath. This increased the FeO content of the slag and the iron content of the bath, diluting the carbon content. Between 5 and 12 lb. of pipe per heat was consumed in various heats.

(c) Temperature regulated by balancing power input against cooling effect of water-cooled induction coil. Increase partially due to exothermic reactions.

(d) These four heats show how final Mn content of metal bath affects the MnO/FeO ratio in the slag.

(e) Sulphur content of base iron 0.05%; final sulphur content of bath 0.03%; of slag 0.07%.

(f) Phosphorus content of slag 0.03%; phosphorus in base iron not recorded, but was much higher than this.

(g) Silica crucibles used in all heats; runs in magnesia crucibles showed higher phosphorus in slags.

level, the rate of iron oxidation increased rapidly. (This work was done in the laboratories of the Union Carbide & Carbon Corp. in 1949.)

Two additional heats containing 7% Mn have since been treated in the same manner to determine the effect of higher manganese. The heats yielded a much larger slag volume, but its composition was 57% MnO, 36% SiO₂, and 6.5% FeO (MnO/FeO = 8.7). This indicates that, when the high-manganese iron is oxidized in a silica vessel, an equilibrium slag of approximately 50 to 58% MnO, 35 to 40% SiO₂ results. This is similar to what occurs in the acid open-hearth or acid bessemer process since any excess of basic oxide reacts with the SiO₂ lining to yield a fairly constant slag analysis.

This phenomenon is also apparent when the residual manganese is plotted against silicon in the bath at different stages, as shown in Fig. 2, wherein the connected points have the same

Production of High-Manganese Slags for Resmelting

The results of these experiments confirm the well-known observations that manganese and silicon are oxidized early in the bessemer blow. Figure 3 describes the change during a typical blow, as reported by C. D. King in his paper "75 Years of Progress in Iron and Steel" in *Transactions of the A.I.M.E.* for 1948, p. 108. Manganese and silicon are reduced to very low values before much carbon goes or nitrogen is picked up. The present experiments indicate that the blow may be interrupted after a large part of the manganese has been oxidized, even from high-manganese pig, and while the bath is still high in carbon. This enables the steelmaker to separate a manganese-rich slag and still have a high-carbon hot metal at an increased temper-

ature—a highly desirable material for subsequent steelmaking operations. The adaptation of such a process to existing steel mill equipment and operating cycles may be accomplished without much difficulty, since the manganese-rich slag might be separated while the metal is in a bessemer converter, in a mixer, or in transfer ladles.

Several significant observations may be made concerning the tests:

1. Slags with a manganese-iron ratio of over 5 may be readily made.

This ratio is highly important in the making of manganese alloys of a suitable grade, and makes these slags superior in this respect to the low-grade African ores which have a Mn/Fe ratio of only 2.5.

2. Slags with very low phosphorus and sulphur are obtained when an acid (silica) vessel is employed for the oxidation.

3. Oxidation of iron is greatly retarded as long as the bath contains more than 0.8% Mn.

4. A desilicized "wash metal" containing about 3% carbon, 0.8% manganese and all the original phosphorus in the pig iron (which has been superheated by the exothermic oxidation of the manganese and silicon) would be highly desirable in accelerating steel production in a basic openhearth.

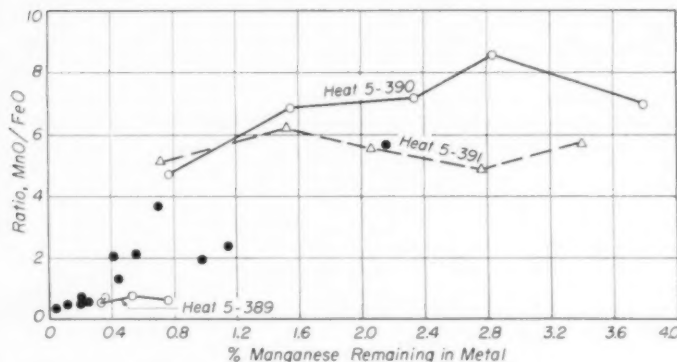


Fig. 1—MnO/FeO Ratio in Slag Versus Residual Manganese in Metal. Data from Table I plus several isolated points from other experimental heats

significance as in Fig. 1. It will be noted that manganese and silicon tend to oxidize simultaneously.

In the first two heats of Table II the oxygen was introduced through a fused silica tube. Material from the hot tube reacts with the basic oxides and dissolves in the slag, thus increasing its silica content. It is believed that this approximates the conditions in the bessemer converter where the bottom tuyeres are rapidly eroded by FeO formed by the air blast. In all the other heats of Table II the oxygen was introduced through a small iron pipe. This pipe dissolved readily in the bath and some of the oxygen also reacted with the red-hot pipe before it could enter the bath. As a result, the slags from these heats contained higher FeO.

An analysis of the data in Table II shows that the higher the initial manganese content of the pig iron, the greater will be the proportion of manganese which is recovered in the slag. Thus, if a 2% manganese pig iron were blown to 0.8% manganese, a little more than half the manganese might be recovered, but if a 4% manganese charge were blown to 0.8%, then about 75% of it would be found in the separated slag. Such a high-manganese pig can be produced in normal blast furnace operation at little extra cost, if the charge utilizes low-grade manganese ores or manganese-bearing slags such as openhearth runoff slags, bessemer converter slags, ladle slags, and some final openhearth slags.

For many years it was standard practice at several integrated steel plants to make pig irons containing 2% manganese. The object was to desulphurize the hot metal more effectively and to obtain a higher residual manganese at

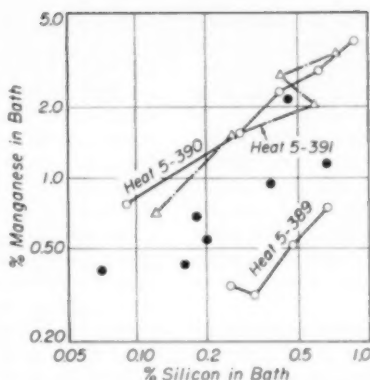


Fig. 2 — Relation Between Manganese and Silicon in Metal Bath (Held in Silica Crucible) During Various Stages of Oxidation; Logarithmic Coordinates. One result for Heat 5-392 (0.11% Mn and 0.01% Si) lies off the diagram

iron, which, when silicon is not objectionable, would be a desirable raw material for the preparation of manganese alloys. Recent estimates sent me in correspondence with metallurgists in the steel industry have indicated that between 100,000 and 200,000 tons of manganese (as silicomanganese) could be used in place of low-silicon ferromanganese for ladle additions in a year of operations which produced 100,000,000 ingot tons.

The metal remaining in the vessel after partial oxidation would contain about 0.8% manganese and 0.10 to 0.20% silicon, along with more than 3% carbon. In some of the heats described in Table II, wherein an iron pipe was used to introduce the oxygen, the final carbon content is below 3%, due to dilution of the bath from the melting pipe; the extent of this dilution reached as high as 30% of the charge. However, the undiluted metal is practically a "wash metal" and, as previously stated, should be entirely suitable for further refining. In fact, because of its low silicon, this should actually accelerate openhearth operations and reduce the lime requirements.

A concrete example of the results possible from this process may be given by calculating the amount of manganese recovered from a pig iron containing 4% manganese. If this pig iron were oxidized to the point where the manganese content fell to 0.8%, slag containing 64 lb. of manganese would be produced from each ton of this pig iron. If 90% of this slag were separated from the bath and shipped to a ferro-alloy plant,

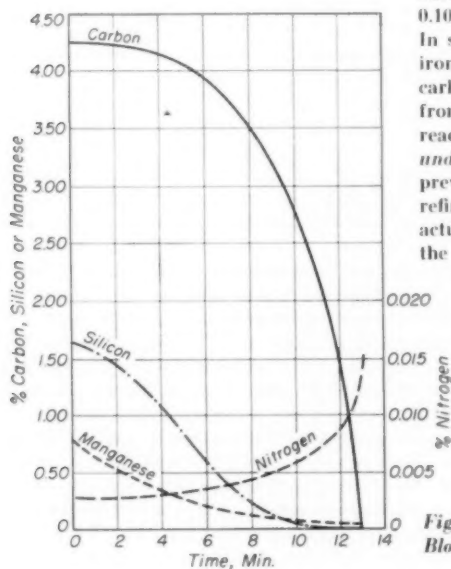


Fig. 3 — Bath Analyses During a Typical Blow in Acid Bessemer Practice (King)

and if 85% of the manganese in the slag were reduced on smelting, 49 lb. of metallic manganese would be returned to useful form as a manganese alloy for each ton of 4% Mn pig iron entering the steel plant. Since the average American openhearth furnace charge approximates 50% scrap and 50% pig iron, a steel plant using this process will thus recover about 25 lb. of manganese for every ton of steel produced from a charge containing 4% Mn pig iron. As was pointed out earlier in this paper, manganese requirements per ton of steel are now between 13 and 14 lb.

Thus, if sufficient manganese is available in domestic ore or slag to an integrated steel plant to make half its pig iron requirements as 4% manganese pig, that plant would be substantially independent of the Government's stockpile. Appropriate burden sheets clarifying this point will be presented later in this article.

Smelting of High-Manganese Pig

Blast furnace burden sheets based on basic Mesabi ores have been calculated for various mixtures of Mesabi and Cuyuna ores, openhearth slags and converter slags so as to produce pig irons with 4% manganese and 0.5% phosphorus with a coke consumption of 2000 lb. per ton and a slag weight of 1200 to 1500 lb. per ton. A typical example is given in Table III. The charge shown in this table was conservatively based on the average dry analysis of ores now in use as reported by the Lake Superior Ore Assoc. for 1949. Actually a much more favorable charge, using higher manganese Mesabi ores and Cuyuna ores with up to 10% Mn, could be employed. Any combination of ore mixes containing an Fe-to-Mn ratio of under 20 would produce a 4% manganese pig iron. (The respective consump-

Table III—Blast Furnace Charge for 4% Mn Pig Iron

MIXTURE	Fe		P		Mn		SiO ₂		Al ₂ O ₃		CaO		MgO	
MATERIAL	Lb.	%	Lb.	%	Lb.	%	Lb.	%	Lb.	%	Lb.	%	Lb.	%
Mesabi ore	2545	56.5	1426	0.075	1.9	0.75	19.0	9.62	242.0	1.00	25.5			
Cuyuna ore	1000	47.8	478.0	0.25	2.5	4.62	46.2	12.26	122.6	3.00	30.0	0.50	5.0	1.5
Openhearth slag	600	13.0	78.0	0.80	4.8	8.00	48.0	16.00	96.0	2.00	12.0	47.00	282.0	8.0
Stone	810	0.50	4.0	0.03	—	—	—	3.00	24.3	1.00	8.0	53.00	430.0	1.00
Coke	2000	0.70	14.0	0.02	0.40	—	—	5.75	115.0	3.00	60.0	—	—	—
Totals			2000		9.6		113.2		600.5		135.5		717.0	

METAL COMPOSITION

Iron in pig	90.0%
Theoretical weight of pig iron	2180 lb.
% of good product	91.7%
Actual pig iron expected	2000
% phosphorus	0.48
% manganese	4.22

SLAG COMPOSITION

Total SiO ₂ in charge	600.5
Less for 1.5% Si in pig	73.0
SiO ₂ remaining	527.5 or 35.60%
Al ₂ O ₃	135.5
CaO	717.0
MgO	71.1
Total	1451.1 lb.
Add 2%	28.9
Total slag	1480.0
Ratio of CaO plus MgO to SiO ₂	1.50

The value of the manganese recovery method described herein can be determined only by actual trials in steel plants. First of all, the greatest benefit would be obtained if the steel industry could bring itself to face phosphorus contents in the pig iron of between 0.5 and 1%, as this would permit the recycling of large amounts of openhearth slags and the consequent production of higher manganese pig irons. Since the Southern steel industry has long operated successfully on hot metal containing 0.80% phosphorus in both stationary and tilting (duplex) openhearth furnaces, it is believed that this difficulty may be overcome. One of the Birmingham plants operates a 3-min. bessemer blow quite skillfully, skimming the acid slag before pouring the wash metal into a basic openhearth furnace.

tion of the low-phosphorus, non-bessemer Mesabi ores and the manganese-bearing Cuyuna ores in 1949 was 43,313,000 tons and 2,362,000 tons—a ratio of 18.5 to 1.)

Calculation will show that a fully integrated steel plant with three blast furnaces and ten 200-ton openhearth furnaces could achieve a balanced operation with respect to slag recycling and manganese recovery by running two thirds of the blast furnaces and openhearths along conventional practices with normal hot metal containing about 0.80% Mn and 0.20% P. These furnaces would produce final openhearth slags

with 8% Mn and 0.8% P — from 150 to 200 lb. per ton of steel.

The other blast furnace could produce 4% manganese iron, and 49 lb. of this manganese could be recovered from each ton of it, with the "wash metal" running through the other three openhearth furnaces. The blast furnace would need 400 tons per day of Cuyuna ore of 6% manganese content, plus the openhearth slag. The plant would require the installation of the necessary bessemer converters for the selective oxidation of the 4% manganese iron. Due to the highly fluid slags produced the converter should be of the horizontal barrel type used in copper smelters. These would overcome much of the stopping and spitting trouble which occurs in the conventional upright bessemer converters with this kind of slag.

Such an operation as outlined above would require 55,000 lb. of manganese per day (13 lb. per ton of ingots) and would recover 45,000 lb. per day from the 1000 tons of 4% manganese hot metal. Similarly, if a 5% Mn pig iron could be made, its use would recover 64,000 lb. of manganese daily.

Phosphorus Control

There should be no build-up of phosphorus in the circuit, since the low-manganese, lower-phosphorus slags from the openhearths on conventional practice (about 250 to 300 tons) would be the only slags recycled. The high-phosphorus, low-silica slags from the openhearths receiving the "wash metal" might be disposed of as a fertilizer. With high-iron charges and runoff slag practice, even better conditions for slag recycling would exist, since the flush slag has a higher Mn-to-P ratio than the final slags.

A steel plant producing such slags could possibly sell them to the ferro-alloy producers. These plants have long been using small amounts of bessemer converter slags to blend with their high-grade imported ores, even though the usual converter slags contain less than 25% manganese. If slags containing over 50% MnO, 40% SiO₂, and 10% FeO are reduced directly, it should be technically possible to make an alloy containing 60% manganese, 15% silicon and 20% iron. This might be used directly in finishing many heats of steel where the silicon may be tolerated. On the other hand, the enriched converter slags may be more economically blended to give a silico-manganese of standard analysis.

The economics of this manganese recovery method may not be accurately estimated at this time since no large-scale trial has been under-

taken. There should be some increase in costs on the blast furnace in making the 4% manganese pig irons, since the slag volume and coke consumption would be increased; the converting of it will impose an additional operating cost, a decreased yield of hot metal for the openhearth, and the cost of slag skimming and slag handling.

A fairly reasonable estimate of the cost of making the 50% MnO slag, taking into consideration the above items, is about 3¢ per lb. of manganese. The low-grade South African ores being imported, which have a similar manganese content, are now selling for about 55¢ per unit of manganese (22.4 lb.) at inland plants. (This approximates 2½¢ per lb.) It is evident that the cost of the slag recycling process described herein is slightly higher, but this comparison is based on a conservative estimate of the cost of the 50% MnO slag at the steel mill. Full-scale use of this method with proper facilities should reduce this figure.

There is no doubt that 4% Mn pig iron can be made without difficulty and it will then yield a 50% MnO slag if it be properly treated. The use of the blast furnace and bessemer converter as concentrating units for manganese recovery thus becomes technically feasible. In the current critical world situation a thorough study of this conservation process, regardless of the economics involved, certainly will be justified on a strategic basis alone.

Summary and Conclusions

A method has been outlined for the concentration of manganese from low-manganese materials, such as low-grade domestic manganese ores and steel mill slags, consisting of smelting the manganese-bearing materials in a blast furnace to produce a high-manganese pig iron, then partially oxidizing the pig iron in a converter to obtain a manganese-rich slag. Small laboratory heats indicated that slags containing 40 to 50% MnO could readily be produced by blowing 3 to 4% manganese pig iron down to about 0.8% Mn. Such slags had MnO-to-FeO ratios greater than 4 to 1, and hence could be utilized in the production of manganese ferro-alloys. The use of acid lined vessels for oxidation of the charge assured a low-phosphorus slag. It is concluded that this method would be of particular interest in a period of national emergency, and that under such conditions an important part of the manganese requirements of the steel industry could be met by using our native, low-grade manganese ores and recycling the steel plant slags. ●

An Eminent Living Metallurgist



Clarence Edgar Sims

Recipient, Albert Sauveur Award, 1950

IN THE OFFICE of Clarence Sims at Battelle Memorial Institute in Columbus something new has been added recently. It is a plaque signifying the fact that "in recognition of pioneering metallurgical achievements which have stimulated organized work along similar lines to such an extent that a marked basic advance has been made in metallurgical knowledge" the American Society for Metals has named him for the 1950 Albert Sauveur Achievement Award.

He takes pardonable pride in this latest honor, just as he was proud of the Penton Gold Medal given him by the American Foundrymen's Assoc. in 1945 and of the R. W. Hunt Award presented to him by the American Institute of Mining and Metallurgical Engineers in 1932. His pride in these symbols is tempered by his clearly expressed awareness of himself as a member of a team, a leader in an effort in which many associates played important parts.

Born in Chicago on July 1, 1893, Clarence Sims appears to have inherited the frugality of his Pennsylvania-Dutch mother and the industriousness of his Cornish father—although a "white-collar" man, he has no abhorrence of grease on his hands or soot on his forehead. He is just as handy with tools as he is with his pencil—a trait that he probably finds as useful in his home as in the laboratory.

Upon receiving his degrees in metallurgy from Illinois and Utah he got his first job in 1916 with the Anaconda Copper Mining Co. Within a matter of three years, Uncle Sam tapped him on the shoulder and Sergeant (f.c.) Sims was in the Research Division of Chemical Warfare Service. Back to civilian life, he joined Aluminum Co. of America at Niagara Falls, but two years later found him with the U. S. Bureau of Mines, first as electrometallurgist at the Seattle Station, and then as Supervising Metallurgist at Pittsburgh—a job he held for two years. In 1927, he moved back to the locality of his birth as Assistant Director of Research for American Steel Foundries in East Chicago, where he spent nine fruitful years. He then joined the staff of Battelle Memorial Institute as Supervising Metallurgist and became Assistant Director in 1947.

In 1920, Clarence Sims was married to Corinne Landgraf, a native of Wisconsin, and took his bride to live in Niagara Falls. Two daughters have enriched their lives. As to his home life, outside of his scientific pursuits, he has no absorbing hobbies. He likes the out-

doors, and has even tried his hand at mountain climbing. His interest in golf is just strong enough to enable him to blow off steam.

Quite active in numerous technical societies he has since 1917 written more than 75 technical articles on subjects ranging the entire field of ferrous metallurgy. His paper entitled "Inclusions—Their Effect, Solubility and Control in Cast Steel" earned him the R. W. Hunt Award in 1932, while his numerous contributions on quality control of steel castings warranted the Penton Gold Medal in 1945. His pet field of research, in which he is recognized as a pioneer and which finally made him an Albert Sauveur Achievement Medalist in 1950, is the interrelation between deoxidation practice and the structure of sulphide inclusions and their influence on the properties of steel. This work led to precision control of foundry practice and stimulated much further work by other metallurgists.

Had our relations with Russia been more cordial, it is quite possible that, for his work on structure and sulphides, the 1950 Medalist would have also been the recipient of the Stalin Award, the Lenin Doublecross, or some similar "honor". Judging from Russian periodicals, his classification of sulphides is generally accepted by Russian steel foundries. His work was republished over there in 1940, when acknowledging contributions from foreign sources was not a capitalistic heresy in the U.S.S.R. It would not be surprising if the original discovery of the relationship between sulphides and deoxidation has now been traced to some Stakhanovite comrade, and Clarence Sims is accused of plagiarism and of being an enemy of the proletariat!

In his research work, Clarence Sims has a keen appreciation of the value of serendipity, a word coined by Walpole for "the art of profiting by unexpected occurrences". It has helped him materially in his metallurgical research. Another characteristic of his which is clearly revealed in his technical writings is the striving to find a simple explanation for phenomena that on the surface appear to be very complex. In this respect, he tries to practice the philosophy of the man in whose name the achievement medal was presented. Albert Sauveur once stated:

The more simple picture of natural phenomena may be rejected by those who believe that a simple explanation proceeds from a simple mind, whereas a complex and confused conception reveals profundity of thought. . . . The laws of nature are always simple and their apparent complexity at times is of our own making.

Clarence Sims has used this as his guide.

Flow Test of

Hubbing Steel

THERE HAS BEEN relatively little attention paid by metallurgists to the technique of "hubbing" or sinking cavities in steel plastic molds and die casting dies. The method is old but not until recent years has the cheap duplication of dies been necessary. This has been due mostly to the rapid growth of the plastics industry.

Hubbing (or "hobbing", as it is often called) instead of machining of cavities, is generally employed when a number of the cavities of the same size and shape are required in a single plastic mold. A button mold is a good example, where the number of cavities varies from a few to over a hundred. A toothbrush mold is another, with up to 24 cavities of the same type in the same mold.

The method consists of forcing a hardened steel hub of the desired shape (a male replica of the female cavity desired) into a blank of softer steel. The work is done in a hydraulic press. Mostly it is done cold without preheating of blanks. Following are a few general requirements for a successful hub:

1. Hardness of C-58 to 60 Rockwell.
2. High compressive strength.
3. High polish, to obtain a similar finish in the cavity—also to reduce friction while hubbing.
4. Ample draft on vertical sides (min. 0.010 in. per in.). The more draft, the easier it is to sink the hub.
5. No sharp corners; as large radii and fillets as permissible.

Hubs are generally made from a good grade of nondeforming oil hardening or air hardening steel. An air hardening steel with high chromium (11.5%) and high carbon (1.5%) will form a large number of cavities.

By Folke Halward

Quarnstrom Tool Co.

Detroit

The steel for hubbing (that is, the die steel) should have the following characteristics:

1. Easy flow.
2. Freedom from segregated impurities.
3. Ability to take a high luster when polished.
4. For its ultimate use, it should be able to acquire the desired surface hardness as well as core hardness after heat treatment.
5. Good compressive strength when hardened.

It is common practice to anneal the blanks before sinking, to relieve stresses and to secure uniform distribution of the carbides. Then the blank is machined to desired size to fit the chase or retaining ring. The surface facing the hub must be flat and highly polished and the opposite side relieved to approximately 60% of the volume of all the hubbed cavities. (This figure is arbitrary and must be based on the shape and depth of cavity.)

A good rule of thumb formula for determining size of blanks for sinking round cavities is to make the diameter of the blank approximately $2\frac{1}{2}$ times the diameter of the hub (limits are usually 2 to 3 diameters). The height of the blank should be $2\frac{1}{2}$ times the depth of the hubbed cavity. A practical limit for depth of cavity lies between 3 and 4 times the diameter of the hub—here again, subject to its shape.

The above-stated qualifications for hubbing steel, listed from 1 to 5, do not always combine with each other. The easily flowing steels generally have low carbon content and must be carburized to obtain usable hardness; this leaves the core soft—sometimes too soft. Other steels having alloying elements to produce satisfactory core hardness and compressive strength, have less "hubbability", and are unsuited for impressions of fine or frail details. Common practice is, therefore, to search for a steel with flow quality capable of reproducing the hub with accurate fidelity, and a desirable core and surface hardness when heat treated.

Choice of steel is vital to both the mold maker, where the wrong selection might break an expensive hub, as well as to the mold buyer, for producing a multitude of satisfactory parts without breakdown in the cavity. Besides flow

quality and hardness there are other important factors to be considered which will determine its usefulness, such as distortion during heat treating, tearing, spalling or seizing at vertical sides of the cavity while sinking.

From the available chemical analyses and the heat treating specifications of the different die steels the mold maker or the mold buyer can determine the hardening qualities. If he has considerable experience he might also judge, to a certain extent, the flow property by appraising the alloying elements. This still leaves much to guesswork.

For this reason the writer devised a test to establish the otherwise unknown "flow property". It is quite simple; the tools are shown in the accompanying drawing.

A cylindrical hub is used, 1 sq. in. in area on its circular end (about $1\frac{1}{8}$ in. diameter). The end is blended into the side with a $\frac{1}{8}$ -in. radius at the corner. The side has 0.005 in. draft per in. (each side). Thus, the hub represents a common shape.

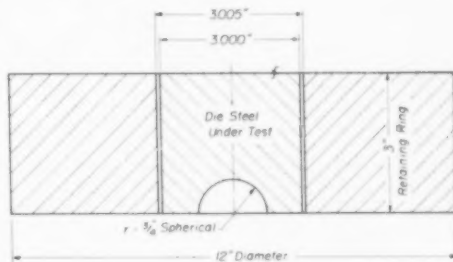
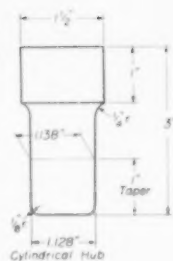
All blanks for testing are machined to 3 in. diameter by 3 in. height and relieved at the bottom by a $\frac{3}{4}$ -in. deep spherical shape.

To appraise a toolsteel, two tests are run: The hub is pressed into the blank with 100 tons pressure, and depth at this load is measured. Next, the hub is sunk into the blank 1 in., and the pressure recorded.

Press speed is $\frac{1}{2}$ in. per min. In our work a 1300-ton vertical hydraulic press was employed. A 3.005-in. (inside diameter) ring provided a 0.005-in. slip-fit for nesting the blank while sinking. Table I shows some results of this test on ten common die steels.

It is well worth noticing that sample No. 3 with a Brinell hardness of 117 and No. 10 with a hardness of 80 required the same pressure (150 tons) to force the 1-in. hub to a depth of 1 in. However, No. 10 permitted approximately 30%

Hub, Blank and Chase for Testing "Hubbability" of Die Steels



deeper penetration at 100-ton pressure (0.622 in. versus 0.416 in.).

Compare this result with figures for samples No. 9 and 10; No. 9 with the higher hardness of 93 Brinell permitted a considerably deeper penetration under 100 tons. It would thus seem that the hardness of a steel is not a good criterion for its "hubbability".

Moreover, by comparing sample No. 2 (130 Brinell) and No. 5 (128 Brinell, almost identical) we find a pair where one is considerably easier to hub than the other. One might suppose, therefore, that the alloying elements and the structure of the steel would affect its flow quality more than the hardness.

There is a need for further study of the flow characteristics, and the development of a stand-

Table I—Results of Hubbing Tests

SAMPLE No.	CHEMICAL ANALYSIS						BRINELL HARDNESS	TONS AT 1-IN. DEPTH	DEPTH AT 100 TONS	PROPOSED HUBBING INDEX
	C	Mn	Cr	Mo	Ni	V				
1	0.10	0.30	5.0	0.90		0.25	130	160	0.290	16-29
2	0.10	0.50	0.60		1.25		130	165	0.213	16-21
3	0.10	0.30	2.30				117	150	0.416	15-41
4	0.07		5.0	0.50		Tr	125	155	0.306	15-30
5	0.15	0.75	(Cold rolled carbon steel)				128	195	0.250	19-25
6	0.07	0.40	1.35	0.20	0.55		107	145	0.464	14-46
7	0.10	0.20				0.10	89	105	0.715	10-71
8		0.25	0.10		4.00	0.50	212	Hub broke	0.025	—
9							93	130	0.864	13-86
10							80	150	0.622	15-62



Moving Picture Cameras and Projectors—Cameras of All Sorts—Use a Multitude of Die Cast and Molded Parts. Photo by Irving Browning

and method for testing. This would give the makers of plastic molds new and valuable assistance for selecting the most suitable hubbing steel for its various applications.

A Proposed Index

An attempt at establishing a numerical criterion, based on the tests described, is made in the last column of Table I. It is a proposed "hubbing number" or index composed by the first two digits from each of the measurements—tons required for 1-in. penetration, and depth of penetration for 100-ton pressure.

For example, the index of 16-29 for sample No. 1 indicates that 160 tons pressure is required

to push a 1-sq.in. hub to a depth of 1 in. and, at the same time, the depth of 0.29 in. was accomplished with a 100-ton pressure.

These two numbers will reveal to the investigator some practical information about the flow condition for the selected hubbing steel and the pressure required for a hub of certain size. Furthermore, it can be used to appraise the value of preliminary treatments. To show this feature, sample No. 2 was reannealed, lowering its Brinell hardness but very little (2 units to 128), yet the 100-ton depth was increased materially, from 0.213 in. as delivered to 0.268 as reannealed.

Possibly the word "index" is not too well chosen, because it might imply that a regular progression of desirability follows the rising or falling number. If this "index" combines a low first number with a high second number, it represents a more "hubbable" steel. Thus, sample No. 7 (10-71) can be hubbed more easily than No. 9 (13-86). It is not to be implied that such "hubbability", desirable though

it may be to the diesinker, is any measure of the utility of the die or mold in service. Until a considerable number of users' records can be related to such a test as the one proposed, such an appraisal cannot be made.*

Generally speaking, such a test will also assist in expressing the hubbing technique in a more exact manner, and enable more precise comparisons to be made. ●

*EDITOR'S NOTE—It is interesting to note that the hubbed dies preferred by Freeman Anderson, chief metallurgist, National Lock Co. (see "Critical Points" for January 1950) for molding plastic articles have compositions similar to sample No. 7 (Index 10-71) pack carburized after hubbing to produce a deep case. No. 1 (Index 16-29) is preferred for die casting dies.

By N. H. Polakowski

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Manufacture of Quality Steel in Russia

IN RUSSIA the term "special steel" covers not only all alloy steels but also carbon toolsteel, and even free-cutting steels high in phosphorus or sulphur. The bulk of such quality material is manufactured in a few works administered by the Special Steel Department (official abbreviation, *Glav-Spec-Stal*) of the Ministry of Ferrous Metallurgy. In addition to handling general problems of man power, production, and supply, *Glavspecstal* also establishes detailed technological instructions which are to be literally obeyed by all concerned, from the works manager down to the meller at the furnace and the roller at the mill. Any departures from this official "cookbook"—often necessitated by the usual shortage of suitable materials and tools—are associated with grave personal risks, including a charge of sabotage. Such orthodoxy is, however, useful on other grounds because it tends to compensate for the deficiency of technical operatives and scarcity of skilled labor.

Major works producing quality openhearth steel are located in Stalingrad, Stalino (Donets Basin), Moscow, Leningrad, Stalinsk (Kuznetsk, Siberia), Zlatoust, Serov, Lysva, and Tshusovoy (Ural region). Four of those works are large integrated plants with blast furnaces of 33,000 to 50,000 cu.ft. volume (930 and 1400 cu.m.), 100 to 250-ton openhearth furnaces with an average capacity of 200 tons, and modern rolling departments headed by 43-in. reversing mills driven by 7000-hp. motors.

The greater part of electric steel production is concentrated in "Elektrostal" (near Moscow), in Zaporozhe, Zlatoust, and Leningrad. In addition many of the larger machine-building works have small electric furnaces and produce toolsteel for their own use. Such are the Stalin Automobile Works in Moscow, the Machine Building Works in Kramatorsk (which makes high speed steel) and the Ball Bearing Works in Gorki (which makes 1% chromium steel). The size of the electric furnaces varies, but 30 tons nominal capacity is quite common for arc furnaces. Four tons capacity was the maximum for the high frequency induction furnaces

installed in the U.S.S.R. up to 1946.

Low-Alloy Constructional Steel—Russian standard specifications for low-alloy steel closely resemble those in other countries. Most of the brands are produced in two grades, the difference lying mainly in the maximum sulphur and phosphorus. Limits for Class A metal (usually electric furnace steel) were 0.04% S and 0.035% P. The chief user of this was the aircraft industry, but the automobile and tractor industries were normally supplied with openhearth material with 0.05% max. S and 0.04% max. P.

Early technological instructions (about 1935) forbade the use of more than 30% low-alloy scrap in the charge. The average charge for an electric chromium-nickel steel, for instance, consisted of the permitted 30% of Ni-Cr scrap, 10% pig iron, 1% ferromanganese, the balance being carbon steel scrap (two thirds heavy). Later on, when the stocks of low-alloyed scrap piled up, a new practice was elaborated so that the higher carbon (0.30 to 0.45%) nickel-chromium steels could be made with up to 70% alloy scrap in the charge.

Not until 1944 did the "Elektrostal" works successfully solve the problem of making low-alloy steel with less than 0.2% of carbon (case hardening quality) from a charge with 50 or 60% scrap and soft carbon steel (below 0.05% C) added to balance.

Stainless and Heat Resisting Steels—Steels of the 18-8 type are produced in Russia both

with and without titanium addition to prevent weld decay. The lower limit is computed from the formula $\% \text{Ti} \geq 5(\% \text{C} - 0.03)$. Production of 18-8 with less than 0.07% carbon was long hampered by scarcity of suitable ferrochromium; furthermore, the ferro manufactured by the Tshelabinsk Ferro-Alloy Works contained up to 2% silicon. This, together with the additional silicon present in the ferrotitanium, often led to rejections due to a specification of 0.08% max. Si in the finished steel.

In spite of Russia's unlimited resources of manganese, stainless steel of the chromium-nickel-manganese type was rare. The 1943 specifications quoted three, two of them being valve steels with about 0.4% C, 1 to 2% Si, 18% Cr, 5 to 7% Ni, and 3 to 6% Mn, and the third a rustless steel with 0.15 to 0.30% C, 0.8% Si, 13% Cr, 4% Ni, and 8 to 19% Mn. I believe that these steels did not enjoy great popularity; seemingly their production was largely a wartime measure.

High-chromium ferritic steels are widely used for high temperature service, such as recuperator tubing. This material presents considerable difficulties, both for the melt shop and also for the rolling mills, and just before the last war the amount of rejects from production defects was often over 50%. Wartime technological instructions recommend that steels with less than 0.15% carbon and 26 to 30% chromium be cast in small ingots—from 700 to 850 lb. Molds are smeared with molasses, are bottomed and have hot tops. Excessive pipe is combatted with a little thermit to superheat the metal in the sinkhead; the sinkhead is then completely filled with reducing slag (white slag containing no carbide) from a nearby furnace. Ingots are cooled in the molds for 10 hr. and their temperature must not exceed 925° F. (500° C.) when removed and placed in the continuous preheating furnace in which they remain for 8 hr., their temperature on delivery being 1925 to 1975° F. (1050 to 1080° C.). In the forge the



N. H. Polakowski

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ingots are hammered down to approximately 5x5-in. squares, cooled in pits, reheated to 1975 to 2050° F. (1080 to 1120° C.) and finally rolled to size on an 18-in. mill.

Resistance wire similar to "Nichrome" is manufactured in very limited quantity and its use is restricted to essentials. Most of the resistance wires are made of "Fechril"; four qualities are available, with alternatively 0.06 or 0.15% max. carbon, 17 or 25% Cr, and 4 to 7% Al, thus resembling the "Megaphyr" or "Kanthal" alloys. Although the Cr-Al-Fe alloys have poor strength properties at high temperature and become brittle after prolonged use, those manufactured in the U.S.S.R. seem to be inferior to the ones produced abroad. As a result of an investigation made about 10 years ago on the life of the heating spirals in electric cookers of Russian make, the present writer found that their average was from four to five weeks. Spare spirals are extremely hard to get "because the country is large and the demand rapidly growing".

Ferro-Alloys—Some typical ferro-alloys produced in Russia are listed in Table I.

High Speed Steel

The prewar high speed steels manufactured in the U.S.S.R. were of the foolproof 18-4-1 type, the best brand ("RK") containing 5% cobalt (recently increased to 10%). Much work has been done by research institutions and by works laboratories since 1935 in order to produce a good substitute containing as little tungsten and molybdenum as possible. The idea of inventing such a phantom steel was neither new nor exclusively Russian, and it led there to the same end as elsewhere—largely disappointing results. For this reason it is of little use to enumerate and describe the various fancy steels developed (mainly by the late Professor Minkevitch in the Moscow Steel Institute with much skill and enthusiasm but with very limited practical success).

As far as I can determine, at present only one such steel with a lowered tungsten content is still manufactured, under the mark EI-262. It contains about 0.9% carbon, 9% tungsten, 4.5% chromium, and 2.5% vanadium, so that it is virtually identical with the medium-quality, German wartime high speed steel. Experience in the Russian machinery industry with this particular steel indicates that EI-262 (and also other high-vanadium high speeds) are inherently difficult to grind and, unless suitable precautions are taken, the cutting edges become "burnt" or rough and saw-like. "Burning" or "blue spots" are caused by local overheating; rough edges are due to the tearing out of small particles of vanadium carbide from the softer matrix. As a remedy, the technical instructions note that grinding speed should be reduced by about 40%, compared with that used for 18-4-1 steel, and that high-vanadium steel should also be avoided for complicated tool set-ups of which great accuracy is demanded.

The writer of this survey believes that the Germans had the greatest experience with low-tungsten, high-vanadium steel, and in this connection it will be of interest to quote their opinion. In Klingelnberg's "Technisches Hilfsbuch", 12th edition, 1944, page 205, it is stated that a steel with 1.2% C, 10.5% W, 4% Cr, and as much as 4.3% V is to be used for thread millers, hobs, cutters for gear generators (of the reciprocating type) and so on, and it is not easy for me to see what cutting instrument is much more complicated and exact than those just enumerated.

As a matter of fact, Metals Handbook, 1948, recommends on page 664 the use of high-vanadium steel (VC2 and VC3) for reamers and broaches. It remains for the reader to judge who is right and who is wrong—whether Americans and Germans have fallen into a "vanadium heresy" or whether the Russians do not know how to make and treat properly a high speed steel with more than 1% V.

Cyaniding of high speed tools is occasionally employed by some of the larger works; increases of tool life of 50 to 100% are claimed. My notes on these recommended processes will now be given.

Gaseous Cyaniding—The gaseous mixture consists of ammonia and of a carbonaceous gas produced by pyrolysis from kerosene, or it can be producer gas, lighting gas, natural, or coke oven gas. Good results were obtained from a mixture of 10 to 15% NH_3 and 90 to 85% producer gas. For 18-4-1 and for EI-262 (high-vanadium) the temperature is 1020 to 1940° F. (550 to 560° C.). Time varies according to size, from 75 min. to 3.5 hr. In order to get a clean surface it is recommended that the tools be cooled in the muffle to about 575° F. (300° C.).

Liquid Baths—Strong baths contain up to 90% NaCN and Na_2CO_3 remainder, or alternatively a mixture of NaCN and KCN (about 1 to 1). Weak baths contain 20 to 30% NaCN, 10 to 20% Na_2CO_3 , 40 to 50% KOH, and NaCl to balance. There are, of course, other intermediate combinations, some containing red or yellow salts— $\text{K}_3\text{Fe}(\text{CN})_6$ or $\text{K}_4\text{Fe}(\text{CN})_6$ —or equivalent sodium compounds. Since 1943 the above quoted weak bath has had some popularity as it is practically nonpoisonous and cheap. The time of treatment is, however, rather long, say 45 to 60 min. for small tools and up to 90 min. for larger ones. Such cyaniding is considered to be the equivalent of a single tempering operation, and normally, if two or three temperings (consecutive) are used, this number is decreased by one. The tool is cooled in air and washed in hot water. Later it is neutralized to remove chemically any traces of salt.

Solid mediums are usually a mixture of yellow salt (30 to 40%) and charcoal. The yellow salt can be replaced by red salt or by appropriate sodium-iron-cyanogen compounds (see above). The temperatures are around 1030° F., the treatment being executed in shallow iron boxes.

Table I—Standard Analyses of the Important Ferro-Alloys in U.S.S.R.

ALLOY	MARK	C	MAIN ELEMENT	Si	Mn	P	S
Ferrochromium (10 grades)	0000	<0.06	55 to 75	1.5	0.4	<0.05	<0.03
	0	0.16 to 0.25	50 to 75	2.0	0.4	<0.05	<0.03
	6	6.0 to 8.0	50 to 75	3.0	0.5	<0.07	<0.05
Ferrotungsten (3 grades)	1	0.5	70 to 80	0.4	0.5	<0.045	<0.05
	3	0.8	55 to 70	1.0	0.7	<0.08	<0.10
Ferro-molybdenum	1	0.1	50 to 65	0.5	—	<0.1	<0.1
	2	0.3	50 to 65	2.0	—	<0.2	<0.2
Ferrotitanium	—	0.2	>18	3.5	5% Al	<0.08	<0.05
Ferrovanadium (4 grades)	1	0.75	35 to 45	2.0	1.0% Al	<0.10	<0.10
	4	1.0	35 to 45	3.0	2.0% Al	<0.45	<0.20
Ferrosilicon-zirconium	—	—	25 to 35	50	—	—	—
Ferromanganese	1	≤1.0	76 to 82	2.0	—	<0.35	<0.025
	2	7.5	76 to 82	2.0	—	<0.30	<0.025
Manganese metal	—	—	91 to 94	—	—	—	—

Refractory Life

The average life of different parts of electric furnaces can be assessed from the following reported figures:

Walls, magnesite brick	up to 40 to 60 heats
tamped blocks	up to 30 to 50 heats
tamped directly	up to 60 to 90 heats
tamped dolomite	up to 30 to 50 heats
Bottoms,	
magnesite tamped with tar	up to 1500 heats
magnesite,	
tamped with sodium silicate	up to 1000 heats
magnesite,	
tamped with molasses	up to 750 heats
dolomite	up to 650 heats
Roofs of dinas bricks	
Average heat, 2 hr.	60 to 90 heats
3 hr.	40 to 60 heats
4 hr.	30 to 50 heats
5 hr.	up to 30 heats

These figures must be accepted with great caution. They are based upon Russian data and are likely to represent top achievements obtained under hothouse conditions. Tricks of this kind are often organized by works managements with the aim of receiving special premiums for efficient use of equipment, although such so-called efficiency is spurious and extremely expensive. Still, even these artificial results are later accepted as norms, and are used for boosting those lagging behind — the well-known speed-up!

According to other official figures the average life of dinas roofs in arc furnaces throughout the U.S.S.R. does not exceed 30 heats, and is appreciably less in larger units of 25 to 30-ton capacity.

Refractories in the U.S.S.R. are none too good. I do not know that metal-cased brick — boxes of thin steel containing tamped mixtures — are used to any extent. A method which has been successfully tried consists of forming the whole wall of an electric furnace in three large segments. These are tamped outside the furnace in a circular mold made of $\frac{3}{4}$ -in. mild steel plates; the mold is divided by intermediate vertical plates in three segments, each corresponding to 120° of the circumferential wall. One of the segments is provided with a core box representing the charging door. Each segment has long eye-bolts passing through, with supporting plates at the bottom, for lifting. After assembling inside the furnace the protruding ends are cut away with an acetylene torch. The mold is disassembled not earlier than 24 hr. after tamping, in order to be sure that the mixture is cold and hard.

Rolling Mills

Contrary to the situation in most West-European countries, where a considerable number of entirely obsolete rolling mills are still in operation, Russia's equipment is largely of modern design. This is easily understood when one realizes that in 1914 Russian production of rolled steel amounted to only 3,000,000 tons, whereas now it is about six times as much. Most of the large steel mills were built in the 1930's either by American or German firms and, except in strip mills, no revolutionary changes have since occurred in mill design.

Recent Russian standard plans provide two sizes of blooming mills, with rolls 35.5 and 43 in. in diameter; the designs are largely based on those built by Mesta Machine Co. and by United Engineering and Foundry Co. Continuous lines for heavy bars and rods have 25 and 18-in. rolls, and the light continuous rod and wire mills have 10-in. rolls.

Most of the strip (both alloy and carbon steel) is rolled in single-stand reversing mills. Only one continuous strip mill had been built at the eve of the war, in the Zaporozhe works; this had to be partly dismantled, and the remainder abandoned during the 1941 debacle. As a whole, strip production is lagging behind other kinds of rolled steel. A considerable percentage of flat products is still manufactured in sheet form on old-fashioned, slow 2-high and 3-high mills.

Tube making plant is modern and varied; it includes piercing mills of the Mannesman and Stieffell types, and also adequate sizing machinery.

The production of bright drawn precision tubing for the automobile and aircraft industries is concentrated in Nicopol and Nishnedneprovsk (Ukraine) and in Pervouralsk (Southern Ural). It is probable that, in addition to requisite drawing equipment, a number of cold Pilger mills of the "Rockrite" type are now in operation in these works. Prototypes could be "imported" from the formerly German part of Silesia. For example, an up-to-date tube mill in Gleiwitz was totally stripped of machinery prior to being transferred to the Polish authorities.

Production Controls

Broadly speaking, quality control in production departments is based on Western, mainly American, practice. This applies to metallurgical control of the charge, bath and slag, the supervision during the pouring period, to chemical analysis, macroscopical and microscopical

examination, hardenability, grain size, and so on.

It is well known to the engineering fraternity in Russia, however, that in spite of the huge number of all kinds of controllers, supervisors, and inspectors, the percentage of scrap produced by Russian factories is high, and the quality of the products unusually low. This is explicable on general grounds, when one remembers the miserable earnings and the lack of incentives and competition for the staff. In an attempt toward improvement, the Russian government "on the workers' request" early in 1941 issued a law "On the Responsibility of Works Directors, Chief Engineers, Department Superintendents, and Production Quality Controllers for the Production of Nonstandard and Low-Quality Goods". This law resulted, in many instances, in effects exactly opposite to those expected by its authors, and also in a cooperation of a unique type, not only within the engineering staff in a given works, but also between the suppliers and consumers in various industries.

After a number of "trials", which immediately followed the promulgation of the above-named law, and in which not only technical operatives but also rank and file workers received sentences of three to 15 years in "corrective labor camps", the amount of scrap radically decreased almost overnight! The reason for this fascinating improvement is perfectly clear: If Comrade X, a director of a machine tool works, will reject two or three shipments of steel from a steel works where Comrade Y is the boss, the latter will certainly soon find his way to jail for producing scrap. But these rejections do not excuse Comrade X from fulfilling his own production plan, and it is not easy to build machine tools without steel. It is exactly as certain that if Comrade X fails to deliver his "plan" over a prolonged period, say a year or so, then his own low performance will bring him to the same concentration camp where Comrade Y is already enjoying a care-free life. A sentence for "purposely sabotaging the Five Years' Plan by throttling output of essential goods" is likely to be even heavier than for the crime committed by the steel plant executive.

The author of this article had innumerable opportunities to see how works and institutions

An expatriate tells of some of the difficulties the steelmaker faces in the "workers' paradise", some of them due to the necessity of conforming — at least ostensibly — to official regulations governing details of technical practice worked out to cover ideal situations. Under these circumstances no fundamental improvements have occurred in the art and science of steel manufacture and treatment. Equipment generally is modern — at least in comparison with West-European mills — since a sixfold expansion has taken place in the last 20 years, an expansion based on prototypes installed by up-to-date German and American firms.

received with thanks and compliments 2-in. rounds instead of the 1½-in. they ordered (which were "just out of stock") and machined them later down to size, or accepted 1-in. gas pipes instead of the required ½-in. size. Of course, both shipper and receiver kept quiet in such deals — in accordance with the unwritten and unique gentleman's agreement, universal in Russia, called *blat* in Russian slang.

Conclusion

There is little that is novel or outstanding in the Russian iron and steel industry, which could be considered as an advance when compared with Western practice. The quality of raw and auxiliary materials is often low. Metallurgists must labor with high-ash coke, fuel oil with up to 2% of sulphur, and admittedly poor refractories — particularly dinas bricks. Tools are scarce, control instruments crude, and spares are usually difficult to get.

Considering all this, one has to give much credit to Russian engineers and craftsmen who produce usable steel under difficult conditions.

It is to be regretted that there are no photographs available to illustrate this article. I doubt whether anyone in the "worker's paradise" ever dared to take one—even if it were a blacksmith's shop in a remote village. I estimate that 15 years in Kolyma would be the lightest possible sentence for such a crime of "spying".



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A 4000° Furnace

IN A STUDY for the Office of Naval Research of the solubility limits of oxygen and carbon in molybdenum (contract N9onr82100) it was necessary to build a metallurgical furnace capable of operating as high as 4000° F. The furnace to be described in this article was designed for this purpose and has filled the requirements very well, both from the standpoint of ease of maintenance and of adequate temperature control. A similar furnace without radiation shields was described by McRitchie and Ault in *Journal of the American Ceramic Society* for January 1950.

The furnace design is shown in the accompanying drawing. The heating element is a tube, 13 in. long and $\frac{3}{4}$ in. diameter, made of 0.005-in. molybdenum sheet. Surrounding this resistance element are a number of radiation shields, also of 0.005-in. molybdenum. The entire assembly is enclosed within a vacuum-tight, water-cooled steel shell.

The molybdenum heating element is not a closed cylinder, but instead there is a $\frac{1}{16}$ -in. slit that runs its entire length. Optical temperature measurements may be taken through this open slit directly on the samples.

The ends of the heating element are tightly gripped by a split ring clamp and internal compression ring, shown in the plan view at the top of the drawing. The top connection is made by horizontal copper bars extending from lead-in busses to the tubular heating element and rigidly clamped to it. At the bottom, the lead-out connection is made by braided copper strap rather than with solid copper bars, which permits vertical movement of the element during heating. The design gives a positive electrical contact at all junctions and prevents any arcing from poor contacts.

Surrounding the heating element is a radiation shield, 10 in. long by $1\frac{1}{4}$ in. inside diameter. It is made by rolling approximately 16 turns of 0.005-in. molybdenum sheet into a

hollow cylinder. The sheets were dimpled slightly prior to rolling to insure a small gap between adjacent turns. They have proved very effective as a heat insulator and have resulted in rather moderate power requirements for operation. In addition, metallic radiation shields do not increase the problem of outgassing and maintenance of a pure atmosphere, as would conventional refractory insulators.

Three holes, $\frac{3}{8}$ in. diameter, are drilled in the shield in alignment with the three sight ports in the outer shell and with the slit running the length of the heating element. The radiation shields are supported from cross-over between the two short busbars, which, in turn, are attached to (and insulated from) the furnace lid. Therefore, when the cover is raised, all internal parts come with it, are easily accessible, and the shell itself is easily cleaned.

Samples are hung in the furnace by a molybdenum wire, which, in turn, is hung on a very fine chromel wire connected between insulated terminals. There are six of these terminals (three diametral pairs) spaced evenly around the top center of the furnace lid. To quench an individual specimen, a small electrical potential is applied across two opposite terminals to melt the fine chromel supporting wire. The specimen then falls into the cooling well, which may or may not be filled with a quenching medium, depending on the cooling rate desired. In this manner, several samples may be run concurrently, even though the times of heat treatment are different.

Temperatures are taken throughout the run by sighting an optical pyrometer directly on the samples through one of the sighting ports in the outer shell. Conditions which closely approach the theoretical "black body" are present within the furnace; therefore the emissivity of the sample does not affect the optical pyrometry. Some correction, however, is necessary for reflection by the Pyrex windows—about 1% of the absolute temperature observed. A fairly uniform temperature zone has been found to exist over the central 9 in. The greatest deviation has been 5 to 10° when operating at 4000° F.

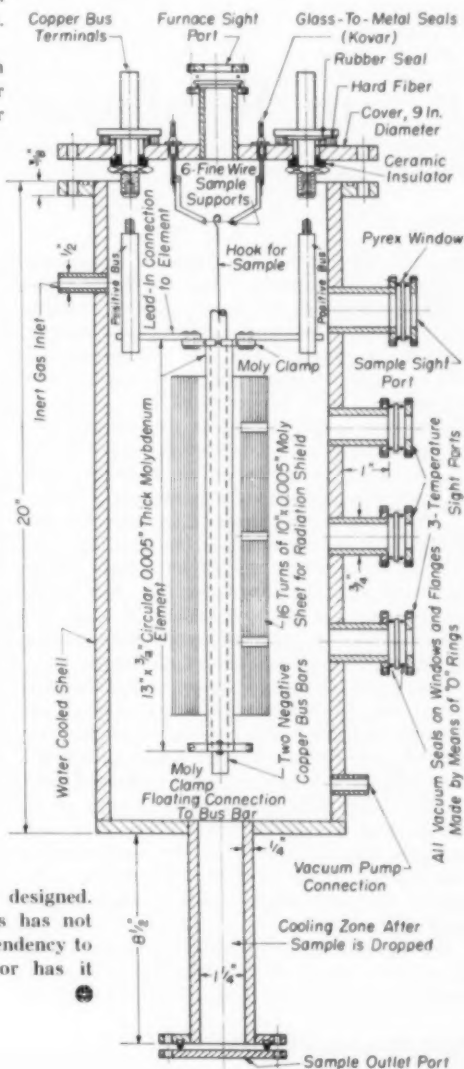
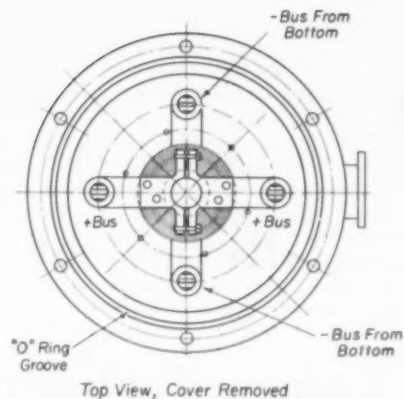
The power input is controlled by a 10-kva. "Powerstat", whose output is fed into a fixed 5-kva. transformer (max. output about 500 amp. at 10 volts). Secondary leads from the transformer are connected directly to the insulated, vacuum-tight busses through the furnace lid. An ammeter and voltmeter provide a continuous check on the power applied. Requirements have been moderate, though they vary somewhat with the atmosphere within the furnace. For example, 1.2 kva. is required when operating at 2500° F. in argon at atmospheric pressure; 2 kva. for 3000° F.; 3 kva. for 3500° F. and 4.4 kva. for 4000° F. If a vacuum (5 microns Hg) is established in the furnace the power requirements are about 20% less, but 25% more power is required if the atmosphere is hydrogen at 100 mm. Hg pressure.

The furnace is mounted on a steel frame with upward extension carrying an overhead pulley for raising the furnace lid, as well as a panel for switches and meters. A small vacuum pump mounted on the floor nearby, the power transformer on the wall alongside, the optical pyrometer movable on a vertical standard, and cylinders of purified gas complete a quite compact and convenient arrangement.

The furnace has been operated for the most part with a purified argon atmosphere, although hydrogen has also been used sometimes. Nitrogen has never been used but could be used, if desired. Purified argon at as low as 5 microns pressure has also been used. (Argon is purified by slowly passing it over hot titanium at 1400° F., then through a magnesium perchlorate drying tower to remove any water vapor.)

The life of the furnace element has been found to be in excess of 150 hr. at 3500° F. The furnace has been used a number of times at 4000° F. The element will not burn out at this temperature before several hours, although the furnace has not been used enough at this temperature to give precise figures. The maximum that is practical with a molybdenum element and molybdenum radiation shield appears to be 4000° F.; higher temperature causes excessive volatilization. However, replacement of the components with tungsten would permit even higher temperatures. A heating element can be replaced simply in less than 30 min. — a marked advantage when compared to the more common wire-wound resistance furnace.

By and large, the furnace has been more trouble-free than was anticipated when first designed. Arcing between the element and contactor rings has not been a problem. The element has not shown a tendency to oxidize locally and thus develop hot spots, nor has it buckled and distorted during service.





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Review of Tracer Techniques in Metallurgy

RADIO-ISOTOPES are valuable byproducts that are now available from Governmental atomic projects in the United States, Canada, and England. Their application to metallurgical problems is already varied and widespread and will no doubt continue to grow in number and importance. It is proposed in this article to review their use to solve (a) problems in ore dressing, (b) problems in smelting and refining, (c) problems in utilization of materials, and (d) problems in physical metallurgy.

Problems in Ore Dressing—Radio-isotopes may furnish the answers to many questions that must be answered before full knowledge of the fundamentals of flotation is secured. With their aid it might readily be possible to trace the movements of the reagents or their ions among the several products of a flotation cell.

Such tracing is done, as one would locate a belled cow, by following the beta rays from radioactive atoms that have been built into the molecules of the flotation reagent under consideration. The beta rays can be measured with a Geiger counter. For example, if a radioactive copper sulphate is used in solution in a zinc float, the Geiger counter can demonstrate not only that the copper left the cell on the zinc mineral but also that a certain definite amount left in that manner.

For example, A. M. Gaudin and P. L. de Bruyn have reported on the behavior of flotation reagents at mineral surfaces in a contribution

to the July 1949 *Bulletin* of the Canadian Mining and Metallurgical Society. These investigators used radioactive carbon C^{14} as the tracer atom in flotation collectors (reagents responsible for making minerals floatable). They used C^{14} because the chemicals used as flotation collectors are usually complex organic compounds. Their actual "labeled" reagents were lauric acid (a normal fatty acid with 12 carbon atoms in its molecule) and dodecylamine (a normal primary amine also with 12 carbon atoms per molecule), and were prepared by J. J. Harwood and A. W. Ralston. Gaudin and de Bruyn are also planning to use

labeled xanthates, alizarin dyes, and amines with longer and shorter hydrocarbon chains than 12 carbons.

Some of their experiments determined the adsorption of dodecylamine on carefully sized and cleaned quartz. Their facts may result in a new theory of adsorption—or at least in one much modified from the theory now usually accepted.

Radioactive surface films on minerals have also been investigated by T. G. Church. He found that certain mineral surfaces can be made radioactive by exchange with radioactive ions in solution, provided the surface is coated with a slightly soluble compound produced by weathering or by chemical treatment. Such radioactive coatings might be utilized in industry, especially for separating certain minerals which are difficult to concentrate by convenient methods, since the number and variety of radio-isotopes now available should make Church's method generally applicable.

Problems in Smelting and Refining—Radioactive tracers should throw much light on the kinetics of steelmaking reactions and some work has already commenced in this field. For example, T. B. Winkler and John Chipman have studied the distribution of phosphorus between liquid iron and basic slag, using radioactive phosphorus P^{32} to determine the time interval required to establish equilibrium. Anhydrous tricalcium phosphate (containing P^{32}) was added

to the molten iron bath after it had reached a steady temperature. After addition of the phosphate, metal samples were taken every 5 min. for 40 min., after which the temperature was raised and samples were taken again every 5 min. The metal samples were exposed to a Geiger counter, which determined the relative amount of P^{32} in each. When the indications from successive samples reached a constant value, equilibrium had been re-established. This occurred within 15 min.

(It has even been suggested that P^{32} added to an openhearth charge as a measured amount of $Ca(PO_4)_2$ could be used to show instantly the amount of residual phosphorus in the metal at any stage of refining or casting.)

The kinetics and the mechanism of the transfer of a constituent across a slag-metal interface are of fundamental importance, due to the fact that so many metallurgical processes involve the coexistence of a slag phase and a metal phase. Industrial processes seldom reach equilibrium; consequently, information of the rates and modes of reactions is often of greater practical value than equilibrium data. Some importance, therefore, resides in a study of the kinetics of sulphur transfer across a slag-metal interface under reducing conditions which has been made by Chang and Goldman. Their aim was to arrive at a better understanding of desulphurization in the blast furnace process. They used radioactive tracers to determine if other elements go with sulphur during the transfer. Indications are that iron is one element that does go with the sulphur from the metal bath to the slag, at least in the early part of the transfer process. An increase in iron content seems to correlate reasonably well with the gradual darkening in color of the slag. However, much more work must be done to establish beyond question the real transfer mechanism.

Both the above researches were reported to the American Institute of Mining and Metallurgical Engineers in Technical Publications No. 1987 and 2367 respectively.

Another reported use of radioactive sulphur is to determine whether sulphur in pyrite (inorganic sulphur) in coal is more likely to remain through the coking operation than the sulphur contained in organic compounds in the coal. There is no perceptible difference. No coke maker would be warranted in paying a premium for a coal of specified sulphur content because it had either a high or a low proportion of "organic sulphur".

Other suggestions involve the use of radioactive calcium to determine the solubility of

calcium in liquid iron, and the calcium-oxygen equilibrium in iron. Refined methods of chemical and spectrographic analysis are not sensitive enough to detect any solubility of calcium in steel, but extremely small concentrations may be found, if some of the calcium atoms are radioactive. This hypersensitivity warrants attempts to use vapor pressure measurements with tagged atoms for determining directly the activity of various chemical elements in liquid slags and metals.

Life of refractories is a prime concern of steelmakers, smeltermen and refiners. They erode and slowly melt when subjected to molten metal. Hence, for example, in the production of openhearth steel it would be of advantage to have answers to the following questions: (a) Are the particles of firebrick and clay removed with the slag? (b) Are any particles of firebrick and clay occluded (hidden) in the steel? Answers to these two questions may be obtained by tagging one of the components of firebrick with a suitable radioactive isotope.

It would also appear possible to use radioactive tracers to secure information regarding the velocity of gas passing through blast furnaces. The use of radon gas in such experiments in Britain indicates much lower velocities than those previously reported.

Problems in Utilization of Materials

Many serious problems arise in the utilization of materials. This is particularly true in the case of metals. Corrosion and friction are two chief enemies in the many industrial applications of metals. Radio-isotopes appear to be of considerable assistance in studying these actions, so important industrially.

Corrosion Studies—It is a well-known fact that when metals and alloys are exposed to air or other oxidizing atmospheres at relatively high temperatures, scaling or oxidation occurs. The usually accepted explanation of the mechanism is that the oxide scales form because oxygen diffuses inwardly and metal atoms diffuse outwardly until they meet and react chemically. Tracer techniques have assisted in the study of this mechanism. For example, J. Bardeen and his associates have investigated the oxidation of copper, using radioactive copper as a tracer (*Physical Review*, 1946, p. 105), and they demonstrated that copper oxide scale grows because of diffusion of copper atoms into vacant positions in the copper oxide lattice at the outer surface of the metal.

Corrosion resistance, on the other hand, is

usually ascribed to the rapid development of a thin oxide layer, practically impervious to transfer of metal ions outward, or oxygen ions inward. Several theories of such "passive state" have been cogently advanced, and radioactive chromium is being used by the U. S. Office of Naval Research to appraise their relative merits as applied to the stainless steels.

C. G. Bacon has used autoradiographic techniques to attack the problem of corrosion. In his procedure, described in *General Electric Review* for May 1949, radioactive iron is placed in an electroplating solution made up in the usual way, and a polished test surface is then thinly plated. The plated surface containing radioactive iron is then placed on the emulsion side of a photographic plate. (A plate-and-developer combination is used to secure maximum contrast.) Exposure is for about three days; the exact length of time will depend upon the initial radioactivity and the age of the iron isotopes used. In his work Bacon used a mixture of two iron isotopes, Fe^{59} with half-life of 47 days, and Fe^{55} with half-life of 4.4 years. This technique appears to give definite conclusions positively and quickly, as for example in attacking the important problems outlined in the next paragraphs.

(Other corrosion phenomena might be studied in the same way, using other radio-isotopes that take part in corrosion reactions.)

When complex alloys (such as stainless metals and high-temperature, high-strength alloys for jet propulsion uses) are oxidized, the components in these alloys do not all oxidize uniformly. Furthermore, the amount of oxidation is not in direct proportion to the average amount of each alloying element present. Radioactive isotopes may determine the role of the various chemical elements in these oxidation reactions in a variety of alloys and in a variety of heat treatments and exposures. Such methods might also be used to secure information about internal or subsurface oxidation of alloys.



G. H. Guest

CANADIAN born (Winnipeg, 1904) and educated (University of Saskatchewan and McGill), Dr. Guest did postgraduate work in organic and biochemistry at the University of Minnesota. He then was teacher in various colleges in Canada until 1947 when he took charge of the Health Radiation Branch of Canada's atomic energy project at Chalk River. Since 1949 he has been senior scientific officer with the Department of National Health and Welfare in Ottawa, specializing in problems concerning radioactive isotopes and health physics.

It is well known that sea water readily pits stainless steels. It is also common knowledge that sea water contains a relatively large amount of common salt. Elementary physical chemistry teaches that when sodium chloride is dissolved in water, its molecules are at once almost completely dissociated into sodium atoms carrying a positive charge of electricity and chlorine atoms carrying a negative charge. These electrically charged atoms (ions) move around freely in the water. It is the chloride ions (Cl^-) in sea water that are responsible for the damage to stainless steels, and the pitting process is being studied through the use of radioactive chlorine.

Corrosion of arsenical brass has been studied by using radioactive arsenic. It has been found that arsenic is redeposited on the alloy after initial corrosion occurs.

It has also been suggested that corrosion rates might be measured by following the movement of radioactive atoms from an irradiated sample into a surrounding liquid.

Research on Wear

Studies of engine wear using conventional methods have been slow, expensive, and difficult to conduct with precision. Accordingly, P. L. Pinotti and his associates have developed a method in which some of the engine parts most subject to wear are given a certain degree of radioactivity. In *Petroleum Engineer* for June 1949, they describe how cast iron piston rings were irradiated in the pile at Oak Ridge, Tenn. After installation in a test engine, wear is measured by determining with a Geiger counter the amount of radioactive metal appearing in the lubricating oil. The top compression ring was selected for the initial study for two reasons: (a) The condition of this ring has an important influence on engine operation; (b) the wear on the cylinder wall is usually a function of the wear of the top ring.

Irradiation of ordinary cast iron in an atomic pile converts about one in a billion of

the iron atoms into radioactive Fe^{59} , with half-life of 47 days. These atoms emit both beta and gamma rays, making it possible for a Geiger counter to detect as little as 1 part per 10,000,000 of iron in the oil which has lubricated the radioactive metal.

In such testing it is important to know that the irradiated rings are of uniform radioactivity throughout, and also that all rings are equal in a group irradiated at one time.

It is interesting to know that a material balance was secured on the iron lost by the piston ring as indicated by the radioactivity of the oil as compared to the actual weight loss. For example, in one experiment in which the motor was operated for 12 hr., the amount of iron worn from the ring as calculated from radioactive measurements was 24.6 mg. as compared to the actual weight loss of 25.0 mg.

Sulphur content in gasoline has been of importance to both the engine builder and the petroleum refiner and its effect has been studied by many investigators. Pinotti used radioactive techniques to find that there is a steady increase of piston-ring wear as the sulphur content of the motor fuel increases, which finding is in accord with earlier publications.

The Adhesion Component

Rubbing of one metal against another metal will, in time, wear away one of the metals involved. The phenomenon of wear is influenced by such factors as the similitude of the rubbing metals, the pressure, their hardness, and the lubrication. In the general process of wear, the sliding metal surfaces tear out extremely small particles on one surface and deposit them on the other. This exchange may occur to such an extent that surfaces seize (weld together). To study the earliest stages of this action, one of the rubbing metals is made radioactive and the surface of the other is examined periodically for activity. Any transfer can be readily detected with a Geiger counter. Sometimes the autoradiographic technique is employed to show the nature and location of the transferred metal. Such a study of this exchange of material has been made by Sakman, Burwell, and Irvine (*Journal of Applied Physics*, 1944, p. 459), who were able to measure quantities of metal as small as 10^{-4} microgram ($1/10,000,000,000$ g.)!

Radioactive tracers have also been used by G. N. Gregory (*Nature*, 1946, p. 443) to determine the amount of metallic adhesion during sliding. By using a small radioactive slider he

obtained a contact photograph of the track it made on a flat metal surface. In general, Gregory found that, as the lubricant reduces the friction, the amount of metallic transfer is also reduced.

These facts support the idea that metallic friction depends on the amount of adhesion between the surfaces, and the lubricant primarily diminishes the area over which intimate metallic contact can take place.

Thus, while lubrication reduces wear and transfer in a system containing rubbing metals, it does not eliminate wear. It is important that information should be available concerning the effectiveness of various lubricants in reducing metal-to-metal contact. Such information can be secured by the metal-transfer method, along with an examination of the used lubricant for its radioactivity.

Another approach to the lubrication problem is to introduce a radioactive tracer into the oil, usually as part of a chemically active radical. Then the radioactivity indicates where in the rubbing system or auxiliary parts the oil reacts or deposits. Using this technique, G. L. Clark and his associates prepared a sulphurized oil containing radioactive sulphur and found that a sulphur-containing film was formed on seven different types of commercial metallic bearings as well as on glass when these materials were exposed to the oil for various times at different temperatures. (This radio-sulphur was prepared with a cyclotron and introduced into the olefin molecules in the oil.) This information (published in *Journal of Applied Physics*, 1943, p. 428) is of interest in the study of the action of extreme-pressure lubricants, running-in compounds, and chemical polishing agents on the rubbing surfaces of gear teeth, piston rings, and the like.

Problems in Physical Metallurgy

Heat treatment and hardening of metals and alloys depend to a great extent on diffusion and reactions in the solid state. While carbon is the chief hardening element in steels, hardening and strengthening of nonferrous materials are usually achieved by age hardening (precipitation hardening). While the later stages of precipitation hardening can sometimes be distinguished under a high-power microscope, the most effective stage occurs when the precipitate is starting to form from a more-or-less uniform solid solution. J. J. Harwood has used radioactive tracers to investigate the kinetics and mechanism of the austenite trans-

formation in steel and the theory of diffusion in binary and ternary systems. His work, published in *Journal of the American Society of Naval Engineers* in 1948 (p. 49), also included a study of the iron-carbon-boron system, with a view to determining the potent effects of boron on hardenability of steel.

Radioactive tracers have been used at the General Electric research laboratory in Schenectady to trace the movement of atoms in an attempt to acquire more information about



James K. Stanley of Westinghouse Research Staff Measures Radiation From C^{14} in a Piece of Carburized Steel, Thus Measuring the Diffusion Constant

internal metallic structure. If we know how the atoms of a given metal will behave under various conditions, there is some hope that metals can be designed for specific tasks.

For example, "self-diffusion" is a theoretical possibility that hitherto has been impossible to prove or disprove. In one experiment it was found that silver atoms within a block of silver may move between the grains as rapidly as 0.1 in. per week at 500° C. On the other hand, atoms passing through rather than around the grains of silver would take about 1000 years

to move the same distance! Work with similar techniques is under way at Metals Research Laboratory at Carnegie Institute of Technology to acquire more information about the structure of metals at the very grain boundaries, so as to reach a more precise idea as to why this material has such different properties than metal within the crystalline grains, and how much there is of it. The Schenectady experiments were conducted with radioactive Ag^{110} , which was electroplated on the surface of an ordinary (nonradioactive) silver block. After several hours at 500° C., the specimen was cooled and layers of silver the thickness of tissue paper were shaved from the block. Each layer was checked for radioactivity with a Geiger counter to determine how far the radioactive atoms had penetrated.

Similar self-diffusion experiments have used radioactive copper to study self-diffusion in polycrystalline copper and in single crystals of copper, self-diffusion in both alpha and gamma iron as it is affected by alloy content, self-diffusion in nickel, and diffusion of Co^{60} in high-temperature alloys.

Self-diffusion in minerals has also been studied by radiographs showing diffusion of radioactive copper ions in the sulphide mineral, chalcocite.

Significance of these results lies in the information gained about the solid state. Carburizing, nitriding, chromizing, siliconizing, and some galvanizing processes involve the penetration into the steel of carbon, nitrogen, chromium, silicon, and zinc, respectively. These are all diffusion processes and can be studied with the aid of radio-isotopes as tracers.

Conclusion

It is apparent from this brief review that there is already considerable use of radio-isotopes as tracers in studying various metallurgical problems. Some others which might be investigated with tracer techniques include the following: Alloying in iron and steels, identification of minor constituents in high-temperature alloys, mechanism of electrodeposition, detection of permanent deformation in a metal stressed beyond its elastic limit, techniques of metal cleaning, accurate measurement of the diffusion of gases through metal, relative volatility of various components of alloys, analysis of low-concentration and complex ores, examination of butt welds, the flow of metal during extrusion, casting, or forging processes, and determination of binding energy. ☐

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Differentiation of Grain Size and Phases in Titanium

ONE OF THE SIMPLEST and most effective means of identifying the phases of titanium or its alloys is by the use of polarized light. A polished, unetched metallographic specimen was found to be best for this examination.

The allotropic transformation which occurs in titanium at about 875° C. (1600° F.) produces a number of different structures whose appearance depends on the composition of the alloy and its cooling rate, in the main composed of one or more of the following phases: alpha or beta solid solutions or compounds of titanium. These phases may appear in several different forms, as may be seen in the accompanying photomicrographs. Identification is aided by the fact that the low-temperature alpha phase, which has a hexagonal close-packed structure, becomes alternately light and dark when illuminated with plane polarized light and rotated about the optical axis of the microscope. The body-centered cubic (beta) phase normally exists only at elevated temperatures, but under certain conditions (as in an alloy with 20% Cr) it may be retained at room temperature. Unlike the alpha phase, the beta phase always remains dark when observed under polarized light.

This difference in behavior is more pronounced on a polished, unetched surface than on an etched metallographic specimen. Irregular

etching or thin films of corrosion products deposited during etching may alter the effect of the polarized light. However, etching tends to enhance rather than mask the effect of the polarized light on equiaxed titanium. This was not true when the alpha phase was present in the acicular form.

For best results, the polished surface must be free from any flowed or worked metal. Titanium alloys (and especially unalloyed titanium) are easily distorted during grinding and polishing. To avoid this, certain precautions are required during the preparation of specimens. The following steps are recommended:

Cutoff—A silicon carbide abrasive cutoff wheel, run wet, should be used for cutting off the specimen. In so doing there is less working of the metal at the cut surface; it also prevents overheating the adjoining metal. Normal cutting procedures may alter the microstructure.

Mount—The specimens should be mounted in bakelite or similar plastic. This assures a flatter surface during grinding; besides, the mount serves as a good holder for the specimen.

Grind the surface through three grades of silicon carbide paper or belts. Silicon carbide abrasive has been found to be superior to the more commonly used emery; grades No. 240, 400, and 600 are recommended. Papers or belts should be lubricated with water or oil, to facilitate better cutting and prevent overheating during grinding. A final grinding step on a well-worn No. 600 paper may be helpful.

Polishing should be done in two stages, using two grades of aluminum oxide as the abrasive. The coarse polishing is the more critical. It should be done on a revolving lap covered with airplane wing cloth (or a fine cotton broadcloth) using 0.3 micron "Precionite Polishing Powder" as the abrasive. A lap covered with "Gamal" cloth charged with 0.1 micron "Precionite Polishing Powder" serves as a final polish. (These two powders are alumina, manufactured by the Precision Scientific Co.) Each



Fig. 1—Forged and Annealed Titanium, Not Etched, 100 \times . Equiaxed grains of alpha phase, viewed under polarized light, one sample rotated 45°

of these steps should take only two or three minutes. Water with a small amount of liquid soap is used as a lubricant. A few drops of a 5% solution of oxalic acid in water is also added during polishing; this appears to prevent excessive flowing during these steps.

Etch—Next, the sample is etched to remove any possible disturbed metal. Several reagents can be used although the most common ones contain hydrofluoric acid and frequently nitric acid. The latter brightens the surface and may prevent staining. Either water or glycerin or both are used as moderators; glycerin may prevent pitting.

Repolish on the "Gamal" cloth to remove the etching pattern is the final step.

At this point the specimen is usually ready for examination under polarized light. If an optically active phase is present and is not well delineated, additional repolishing and etching may be required.

Figure 1a (at left) shows equiaxed grains of alpha titanium as delineated by polarized light on an unetched surface. Figure 1b is the same area rotated 45° in respect to Fig. 1a. This material, as well as that shown in Fig. 2, was forged at 1700° and annealed at 1300° F.

Figure 2 is of the same area as shown in Fig. 1 after the specimen was lightly etched with 5 HNO₃, 1 HF and 94 H₂O.

Figure 2a was made with polarized light, Fig. 2b the same as 2a but the specimen was rotated 45°, and Fig. 2c was made with brightfield illumination.

Etching equiaxed titanium tends to enhance rather than mask the effect of the polarized light. It was found that this was not the case when the alpha phase was present in the acicular form (Fig. 3).

Beta grains may also be equiaxed but are usually larger than alpha grains and can be distinguished from alpha by the fact that they do not change color when exposed to polarized light and rotated. (See Fig. 4.) No grains or grain boundaries are visible in beta under polarized light before the specimen is etched.

The higher power micrographs of Fig. 3

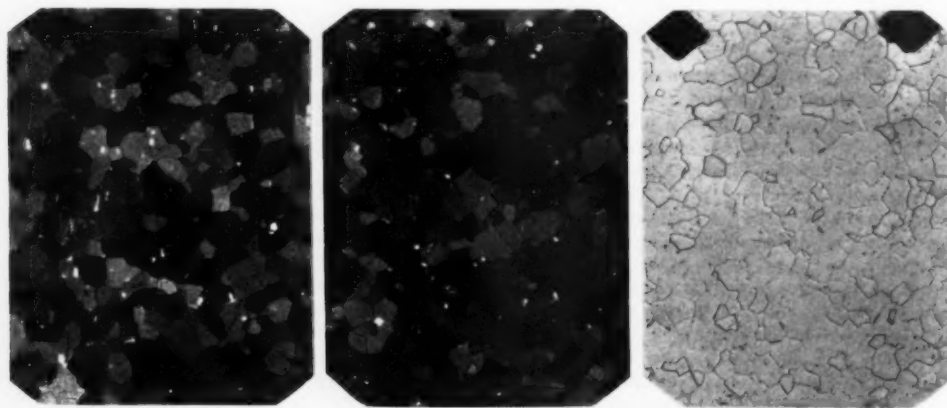


Fig. 2—Same Area as Fig. 1 After Etching With HNO₃-HF Solution. 100 \times . Photographed respectively under polarized light, same but rotated 45°, and brightfield

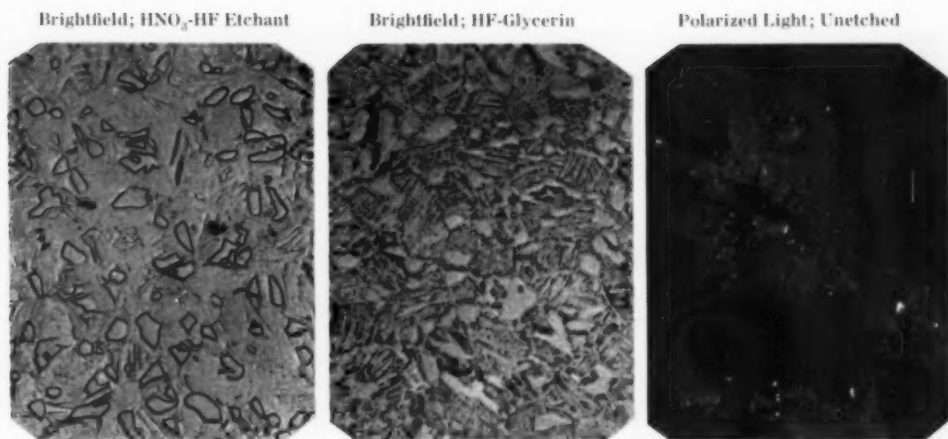


Fig. 3 — Primary Alpha Titanium (Well Outlined Particles in View at Left) in a Matrix of Acicular Alpha or Transformed Beta. 500 \times . Original grains shown under polarized light

are examples of primary alpha in a matrix of acicular alpha produced by a beta-to-alpha transformation in titanium containing 0.25% nitrogen, water quenched from 1750° F. The specimen shown in Fig. 4a was etched with 5 HNO₃, 1 HF and 94 H₂O; this outlines the primary alpha but fails to bring out the transformed alpha clearly. In Fig. 4b the reagent consisting of 1 part HF to 1 part glycerin was used to emphasize the transformed matrix. In neither of these is the grain size apparent; Fig. 4c, taken of an unetched surface under polarized light, clearly outlines the original grain size.

Retained beta is found at room temperature in some titanium alloys—for example, 80-20 Ti-Cr, or titanium with 2.7% Cr and 1.3% Fe (Fig. 4). Large needles of alpha in a matrix of retained beta are shown in Fig. 4. The alpha is clearly delineated by polarized light on the unetched surface, while the beta phase is unaffected and remains dark when the specimen is rotated 45°.

The right-hand view of Fig. 4 is this same area as it appears under brightfield illumination after etching. This sample was heated 2 hr. at 1700° F. and cooled in the furnace, then reheated 2 hr. at 1500° F. and water quenched.

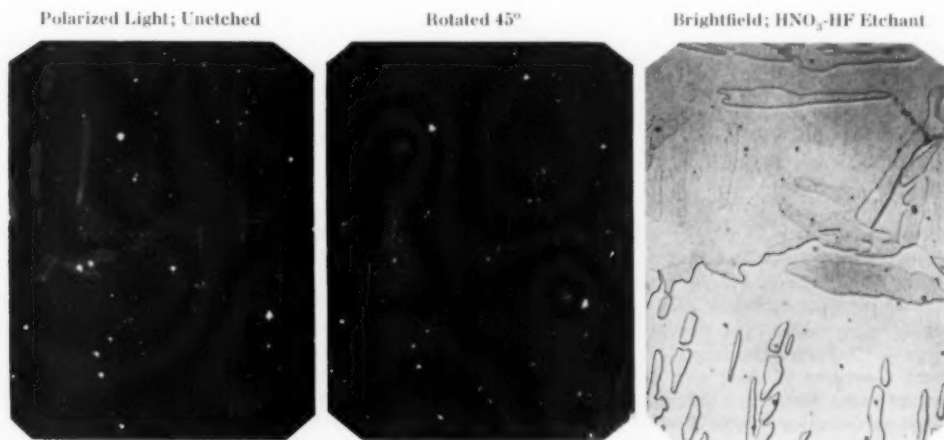


Fig. 4 — Islands of Alpha in Matrix of Retained Beta. 500 \times

Correspondence

A Decade of Metallurgical Science

WEMBLEY, MIDDLESEX, ENGLAND

I have read Dr. Cyril Stanley Smith's shrewd survey of "A Decade of Metallurgical Science" in the October issue with pleasure and with appreciation of the breadth of view and balanced judgment it displays, and I hope he will not think me ungrateful if I question one isolated — but I think not unimportant — suggestion. Referring to the results of investigations of internal friction with the torsion pendulum, he writes: "The absorption of energy by the sliding of one grain upon another has been measured The old amorphous metal hypothesis — enunciated 40 years ago by Rosenhain — has been revived."

I venture to prophesy that the revival is likely to be short lived. It has always seemed to me impossible to conceive that a crystal aggregate can deform by viscous flow at a grain boundary layer which is 50, 100, or even 1000 atoms wide. In a normal closely-fitting array of polyhedral crystals, any attempt to move the crystals in this way can be accomplished only by widely separating many of the crystal boundary surfaces. Such work as that of Calnan and Burns, published in the *Journal of the Institute of Metals* (Vol. 77, 1950, p. 445), makes it abundantly clear, on the other hand, that it is quite possible (and, indeed, perhaps the normal thing) for various regions of a crystal to deform at differing rates. The conclusion seems inescapable that whenever grains have appeared to past observers to slide over one another, the action must have been accomplished by severe local deformation of the crystals in a relatively wide region on each side of the crystal boundaries.

Finally, may I be allowed a tilt at those experimenters who carry out torsion tests on wires gripped at the ends? How they get away with it is to me an ever-puzzling mystery. The first lesson an inspector of raw materials learns is to be suspicious of the results of any tensile test on a specimen which is not provided with generously enlarged ends, merging smoothly to the parallel gage length. Yet far-reaching theories are cheerfully based on torsion tests on wires in which severe stress concentrations must inevitably exist at the ends where they enter the chucks — stresses

which quite conceivably are large enough to cause local plastic yielding. Surely it is a woefully retrograde step to employ wire specimens in any torsion pendulum apparatus.

J. C. CHASTON

Chief of Metallurgical Research
Johnson, Matthey & Co., Ltd.

Rejoinder

Dr. Smith suggests that the following comment by his colleague, Clarence Zener, be printed *in extenso*:

"Mr. Chaston has had the courage to voice objections which many others may have harbored in silence. A reply is therefore in order.

"These criticisms of the torsion pendulum technique, and of the conclusions derived therefrom, as well as other criticisms which have at times been raised, spring from a too-narrow channeling of one's thoughts by past experience. It is quite true that it is difficult to conceive of a mechanism whereby viscous flow may occur at grain boundaries. It is also true that experiments may be performed in which an apparent gliding of one grain over another is accompanied by severe local deformation of the grain interior. Such truisms do not, however, outrule the possibility that under certain carefully specified conditions, of a type not usually met in the laboratory, grain boundaries may flow in a viscous manner without an accompanying plastic distortion of the grain interior. Our intuition, built up by years of experience with deformations greater than 0.1%, cannot be a safe guide in predicting what happens when the deformations are less than 0.001%. Only strains of this order of magnitude are used in the torsion pendulum.

"It is quite true that a raw-material inspector learns in his first lesson, and rightly so, to be suspicious of any stress concentrations. It is likewise true that any engineer skilled in determining relations between stress and strain or strain rates would be horrified at the inhomogeneous stress system in our torsion pendulum specimens. Thanks to the linearity of the relation between stress, strain and their time derivatives at very low stress levels, we are not hampered by fears of stress inhomogeneities (in particular, of stress concentrations) and hence we cheerfully and confidently make far-reaching theoretical deductions based upon the visual decay of the torsional oscillation of a wire gripped at the upper end by a chuck for support, and at the lower end by a second chuck which carries the inertia arm."

CLARENCE ZENER

Correction

The third and fourth sentences of the last paragraph, "Galvanic Macro-Etch for High Purity Aluminum" (*Metal Progress*, November 1950, page 732), should have read: "The lower rod in the illustration (grain size 0.5 to 1.3 mm.) was annealed 30 min. at 700 to 750° F. The middle one (grain size 3.5 mm.) was annealed 30 min. at 1100 to 1150° F."

Spinning Flanged and Dished Wrought Iron Heads

PITTSBURGH, PA.

Flanged and dished wrought iron heads are produced by a process commonly known as "spinning" in which temperature, spinning speed and roller application govern the operating procedure. Recently, a large fabricator met some difficulty in production of three pairs of flanged and dished heads from special forming wrought iron plates supplied by our firm. The job called for two heads $\frac{1}{2}$ x 48 in. o.d. x 48 in. dish radius A.S.M.E.; two heads $\frac{3}{4}$ x 48 in. o.d. x 43 in. dish radius ellipse A.S.M.E.; and a pair of heads $\frac{1}{2}$ x 66 in. o.d. x 66 in. dish radius A.S.M.E.

Modifications of procedure included heating the heads twice, reducing the spinning speed, and applying the roller so that greater surface contact was made between the roller and the forming plate. Plates were heated to obtain a metal temperature not higher than 1450° F. at the time spinning began. Spinning continued until temperature dropped to a range of 1100 to

1150° at which the plates still glowed a dull red. Plates then were reheated to continue forming at not greater than 1450°.

The fabricator's machines are geared to a high speed of 80 r.p.m. and a low speed of about 30 r.p.m. It has been found that high speeds tend to tear the surface at the point of roller application, especially during formation of the flange. High-speed spinning also tends to markedly accentuate the effects of the lamellar structure of wrought iron.

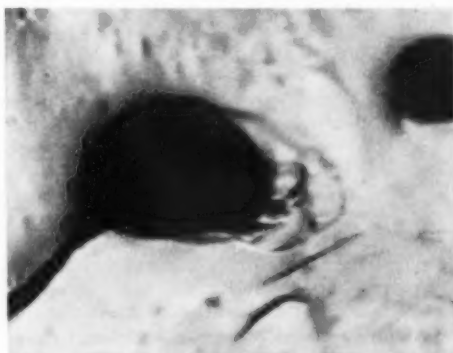
The final modification was the elimination of the customary practice of playing the spinning roller in the early stages on the peripheral edge of the plate. This change was made because in the original practice the roller caused localized compression and tension stresses in the plate. These stresses were reduced when the roller was applied to a greater surface area of the plate. Formation of the elliptical heads could have been troublesome because as the radius of a dished head decreases and approaches a sphere, the forming operation becomes more severe.

EDWARD B. STORY
Chief Metallurgist
A. M. Byers Co.

Mouse and House

BALTIMORE, MD.

Mr. Mouse, chief metallurgist, Pantry Products Corp., is shown here wearily dragging himself home at 4 a.m. after a tough shift on a pickling operation. Double-exposure effect probably is due to nervousness of the subject. The



dark areas are carbides in 99.6% chromium metal which was melted with an electric arc and cast in vacuum. 2400 \times . Mice fractograph, eh?

C. A. ZAPFFE and F. K. LANDGRAF

A New Type of Cupola

LONDON, ENGLAND

A new type of foundry cupola, called the "metallurgical blast cupola", has been working for over a year in Liege, Belgium, producing an average of 1200 metric tons of iron per month. Tests indicate that the iron produced by this cupola is in certain respects superior to that made in the conventional cupola. The cupola resembles a miniature blast furnace; there is external water cooling, a hot blast is provided, tuyeres are water cooled and it uses gas manufactured at the site. One of its innovations is that the water-cooled tuyeres extend into the cupola about 10 in. beyond the lining, leaving a heating zone diameter of about 34 in. between the tuyeres. As there is a wall of comparatively cool coke between the tuyere nozzle and the furnace lining, there is no attack upon the refractory. However, slag control takes on a new and probably more difficult aspect.

The melting zone, confined to a short distance above the tuyeres and restricted in area, operates at very high temperature. Although the metallic charges reach this zone at a comparatively low temperature, they are very rapidly melted. They quickly traverse this zone and then pass through a deep and likewise very hot slag to reach the hearth. A second important feature is that only the materials charged in the stack enter into the slag. Slag dilution resulting from wall attack does not exist because the refractory is scarcely touched. The high temperatures attained permit the formation of

certain slags which, in the normal plant, are difficult to fuse and would cause bridging and other difficulties.

With this plant it is possible to obtain any particular iron whose composition is compatible, according to the laws of chemical equilibrium, with the slag it passes through. The reducing atmosphere maintained in the furnace prevents metallic losses. Analyses show that the slag contains less iron and manganese than is brought in with the coke ash.

The iron is tapped at an exceedingly high temperature (above 2700° F.) so that it is easily possible to create, initially and from a unique mix, a series of special or alloy irons well suited for inoculation, alloyed either at the spout or in some sort of mixer ladle. Low quality coke can be used and metallic oxides can also be charged. The monthly yield from the plant is very high, as no repairs are needed.

Just as there are advantages resulting from the fundamental characteristics of the plant, there are also inherent drawbacks. The plant is sensitive because reactions are completed very rapidly at this high temperature. The homogeneity of the raw materials charged—especially those of a nonmetallic nature such as coke ash and limestone—is highly important. The plant is obviously much more expensive than an ordinary cupola and it requires more extensive use of control instruments. Although cupolas have provided the cheapest and most economical method of melting, they are—as has been shown in recent times—capable of being modernized to advantage.

TOM BISHOP

Emergency Steels

Boron Steels—Three types of "triple alloy" steels containing boron (to conserve other alloys) have been accepted by American Iron & Steel Institute and "are in the early stages of production".

80Bxx steels have the approximate hardenability of 8600 steels of the same carbon content. They contain about 0.30% Ni, 0.25% Cr, and 0.12% Mo. Manganese increases from about 0.60% for the low carbons to 0.85% for the high carbons. The following grades (each with the usual carbon spread) are listed: 80B20, 80B25, 80B30, 80B35, 80B40, 80B45, 80B50, 80B55, 80B60.

81Bxx are designed to substitute for 4100 series. The following four grades are listed:

81B35, 81B40, 81B45 and 81B50. In these the chromium is up to about 0.45%.

94B17 is also available with hardenability equivalent to 4820. In 94B17 the chromium and nickel are both higher than in 80Bxx—about 0.45%.

New Triple Alloys—Series 8100, with 17 carbon grades ranging from 0.15 to 0.60%, is established to conserve molybdenum. The alloy content in this series is 0.70 to 1.00% Mn, 0.20 to 0.40% Ni, 0.30 to 0.55% Cr, and 0.08 to 0.15% Mo.

Modified 8600 series steels are also available, wherein the chromium has been raised to 0.55 to 0.80% range, and the molybdenum reduced to the 0.08 to 0.15% range.



View of Harbor Island Laboratory and Testing Station.

New testing station provides expanded facilities for corrosion studies

During the past 15 years, the Atlantic Ocean at Kure Beach served as a giant test tube for studying attacks of sea water and salt air upon more than 35,000 specimens, including virtually all types of metals and alloys.

Storm damage to the basin, in which the underwater tests were conducted, compelled establishment of a new and protected testing station. Accordingly, some 15 miles north, on Harbor Island, the new Inco Marine Laboratory was built to provide expanded facilities and an even better "Ocean Test Tube."

This new Harbor Island station, along with the atmospheric test racks retained on the shore of Kure Beach, now widen the scope of cooperative enterprise for fighting industry's common enemy — corrosion.

The vast amount of valuable data accumulated over the years will continue to be made available to all industry, as well as to government agencies for whom and with whose cooperation much of the research has been undertaken. You are invited to consult us on your corrosion problems.



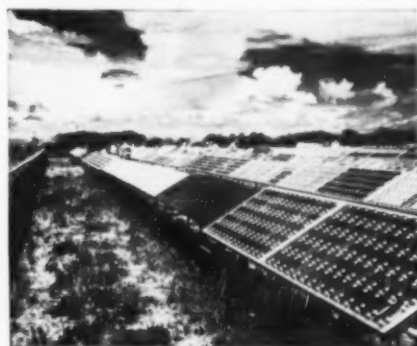
THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET
NEW YORK 5, N.Y.



Lowering piling test specimens into place. Sea water is something more than a mixture of chemicals; its corrosive action over an extended period can be studied properly only by exposure of specimens to attack under natural conditions.



Running water troughs. For studying the action of sea water flowing at moderate velocities, specimens are immersed in the troughs, shown above. The total length of trough used for this purpose now amounts to about 600 feet.



Atmospheric and spray test lot. Shown above is part of the atmospheric test lot at Kure Beach in which over 20,000 specimens have been exposed, some for over nine years. The racks face south, and the specimens, supported on porcelain insulators, are all set at a slope of 30 degrees.

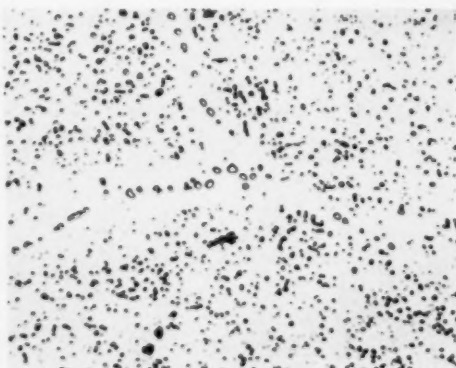
Etching Sigma Phase

By John J. Gilman

EXAMPLES of various modes of etching Type 314 stainless steel (25-20 with Si) heat treated to produce sigma at grain boundaries and in Widmanstätten pattern. Sample heated 1670 hr. at 1500° F. Lightly repolished before each etch. Magnification of all specimens: 500 ×.



10% Oxalic Acid (Electrolytic), 1.5 volts, 20 sec. Specimen black and white, the austenitic matrix being dissolved *less* rapidly than the other phases. Photographed with green filter.



10% Cadmium Acetate (Electrolytic), 6 volts, 0.6 sec. Carbides stain more rapidly than sigma. In specimen, grain boundary carbides are gray, others are black. Photographed with green filter.

Saturated NaOH (Electrolytic), 1.5 volts, 6 sec. Sigma stains more rapidly than other phases. In specimen, sigma is blue. Photographed with green filter.



Vilella's Reagent (5 ml. HCl, 1 g. picric acid, 100 ml. alcohol), 35 sec. Specimen black and white, austenitic matrix being dissolved *more* rapidly than other phases. Photographed with green filter.

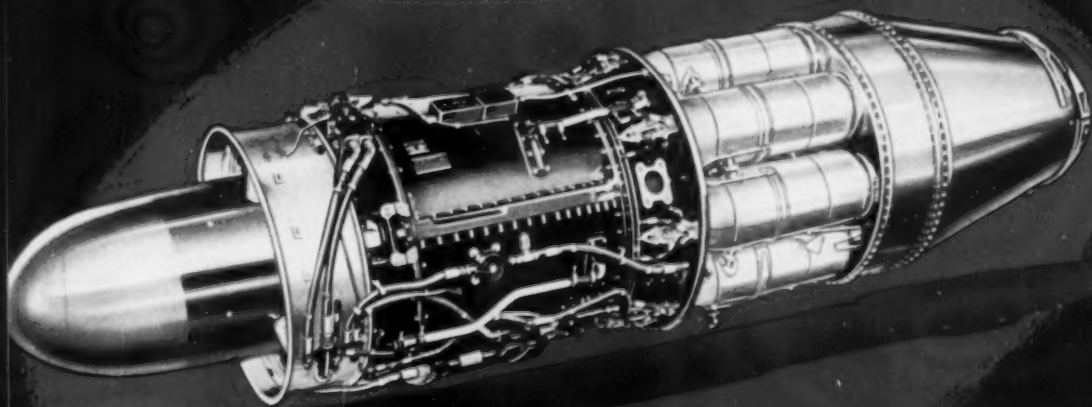
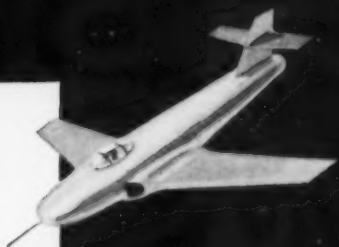


10% Lead Acetate (Electrolytic), 6 volts, 0.6 sec. Films on constituents whose color varies with etching time. In specimen shown, austenite was light blue, sigma dark blue, carbides tan. Photographed with yellow filter.



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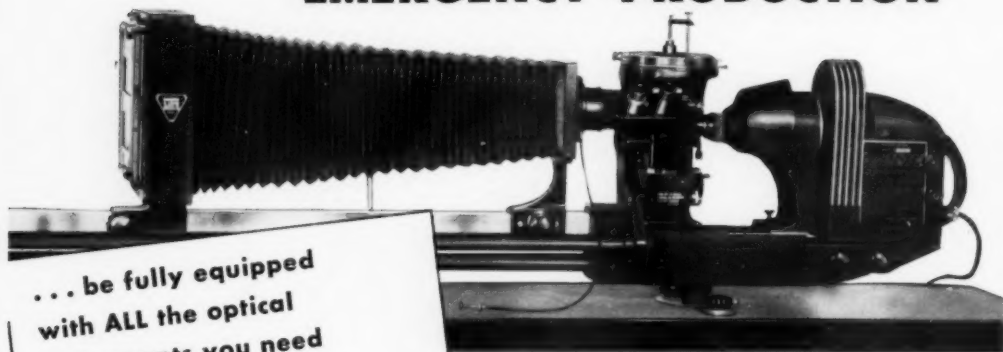
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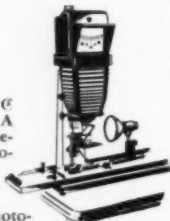
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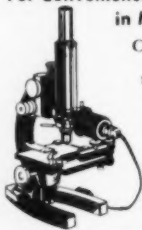
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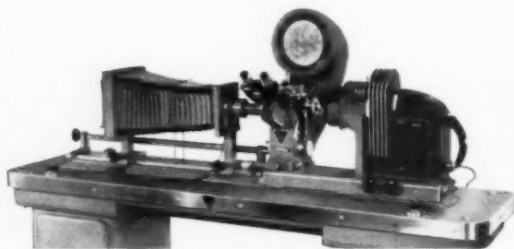
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Bausch & Lomb Metallurgical Equipment



By John J. Gilman
Research Laboratory
Crucible Steel Co. of America
Harrison, N. J.

Etching Steels Which Contain the Sigma Phase

IN AN investigation of etching reagents which are suitable for the detection and study of the sigma phase in high chromium-nickel-iron alloys, it was observed that the modes of attack are quite varied. Some of these modes have been reported previously but not all of them, and it is thought that a single, brief presentation of the ones we find most useful might be worth while.

Constituents of steels may be revealed to the metallurgist by an etching reagent in either of two ways: First, part of the polished surface of a microspecimen may be *dissolved* by the etchant. Second, part of the surface may be *stained* by a thin film of corrosion products. However, there are several variations of these two basic mechanisms. An etchant may dissolve either the matrix, or one or more of any minor constituents existing there, or it may stain one or more of these phases. Some of these variations which appear when examining a specimen of steel which contains the sigma phase are shown in the photomicrographs in the data sheet, page 376-B.

The five pictures show the same field of a specimen of Type 314 stainless steel (25-20 with silicon). The specimen had previously been heated for 1670 hr. at 1500° F. This treatment resulted in the formation of the sigma phase along the grain boundaries and in a Widmanstätten pattern within the grains themselves. Many tiny particles of residual carbides were

also present. The specimen was repolished prior to each etching operation.

Vilella's hydrochloric-pieric acid reagent was the etchant for the first photograph. This dissolves the austenitic matrix of this type of steel more rapidly than it dissolves either the carbides or the sigma phase. The latter constituents stand out in relief against the background (top right).

Just the opposite mode of attack is exhibited by oxalic acid used electrolytically. This etchant attacks the sigma phase and the carbides before it attacks the matrix. The result is that the carbides and sigma are gray, outlined in black, and the structure appears as in the second photograph (top left).

An entirely different effect is produced by the action of an aqueous solution of lead acetate used electrolytically. This chemical causes the surface of the specimen to be stained with a thin film (possibly ferric acetate) which forms most rapidly on the austenite of the matrix, less rapidly on the sigma phase, and least rapidly on the carbides. As the thickness of the film is built up its color changes. The colors of the austenite, sigma and carbides were light blue, dark blue, and tan respectively when the third photomicrograph was exposed. Depending on the etching time, these phases appear yellow, red, purple, blue, and brown (middle right).

The last two photographs show the structures produced by etchants which are quite selective in their attack. Left, below, cadmium acetate, stains carbides more rapidly than it stains the sigma phase; this mode of attack resulted in the structure shown in the fourth photograph. Finally, a concentrated aqueous solution of sodium hydroxide stains the sigma phase before it stains the carbides or matrix and thereby it produced the etch shown in the lower right photograph in the data sheet.

Etchants which attack polyphase steels in different modes have much value to the metallographist for the detection and study of sigma phase. Those of high selectivity are especially valuable. While cadmium acetate and sodium hydroxide are quite useful etchants, a further search for selective etchants is desirable. ☐

By S. L. Case
Technical Adviser
Battelle Memorial Institute
Columbus, Ohio

Corrosion Resistance of Wrought Iron and Steel Pipe

A SURVEY of the technical literature on the relative corrosion resistance of wrought iron and steel indicates that the marked superiority frequently attributed to wrought iron is more reputation than fact.

In comparing these materials, one must bear in mind that wrought iron had an ancient and honorable history, dating back almost 2000 years, while steel first came in quantity only about 80 years ago. It was therefore natural to view steel as a suspicious newcomer. The hazardous way in which steel was manufactured prior to 1900 did not do much to enhance its reputation. These were the tangible reasons why wrought iron, a product made by highly skilled craftsmen, demonstrated at that time its superiority in their competing fields.

As time went on, the art of steelmaking became better understood, specifications were tightened up, and general quality and uniformity of the product were raised. Simultaneously any disparity in corrosion resistance of steel and wrought iron disappeared.

For example, soil-corrosion tests, conducted by the National Bureau of Standards since 1932, as well as carefully conducted tests by the corrosion committee of the British Iron and Steel Institute, clearly indicate that differences in the resistance of various wrought irons are often greater than the differences between wrought

iron and steel. In soil-corrosion tests, atmospheric-corrosion studies, and investigations of hot water and steam return lines—in fact, under any tests that simulate service of radiant heat panels embedded in concrete—the behavior of mild steel was not strikingly different from that of wrought iron.

In 1908, Howe and Stoughton reviewed the subject in the *Proceedings* of the American Society for Testing Materials. They concluded that:

"The theory that steel is intrinsically and incurably more corrodible than wrought iron is contradicted flatly by the evidence. It, therefore, must be abandoned unless resuscitated by correspondingly direct, convincing, and abundant counter-evidence, clearly relating to well-made modern tube steel. Nobody doubts that ill-made steel may misbehave. The distrust of steel may be nothing but a survival from a day when it was justified, or it may be only an unjustified inference that, because some steel corrodes badly, all must. The distrust can be explained away, the evidence cannot. Therefore, the evidence and its implications must stand till refuted."

Iron and steel rust or corrode under nearly all service conditions where they come in contact with air, water, or soil. The oxides and hydroxide of iron are chemically more stable than the metal, so rusting is a natural phenomenon when ferrous materials are exposed to an environment containing oxygen and moisture. The objective of this present literature survey is to evaluate the relative corrosion under conditions approximating those of radiant heating installations where metal pipes are embedded in the structure of a building.

The nature of this environment is indicated by the floor constructions shown in Fig. 1. It is quite evident that floor panels may sometimes be subjected to rather severe corrosion condi-

tions. Although protected by concrete, they may be partially embedded in gravel and located close to the soil. Moisture, air, and so-called "anaerobic" organisms which can cause corrosion in the absence of oxygen, may pervade such an environment.

While soil-corrosion studies are most pertinent in evaluating service in radiant-heating installations, atmospheric-corrosion studies, as well as data on the performance of both materials in hot water and steam lines, should also prove illuminating.

Fundamental Structure—There is no need to dwell in *Metal Progress* upon the fundamental difference in microstructure between wrought iron and low-carbon steel, nor their manufacture. Wrought iron consists of small grains of relatively pure ferrite containing parallel slag sheets and particles arranged in planes squeezed into position by rolling or forging the hot metal. Mild steel, if reasonably clean, has very few slag inclusions; its structure is of ferrite grains (usually considerably smaller than those in wrought iron) and small patches of fine pearlite. The above-described structure of wrought iron is the same whether the iron has been made by hand in the traditional puddling furnace or mass produced in the modern Aston process now used in the United States. Both have about 2% of slag.

This difference in basic structure has aroused much argument. Many claims of great superiority, based on the presence of slag fibers and on alleged greater purity of the ferrite, were made by partisans of wrought iron. (From a metallurgical standpoint, there is no valid claim for unusual purity of the iron base in wrought iron; its purity depends on the purity of the pig iron from which it is made, since the only impurities removed in manufacture are carbon, manganese, and silicon.) On the other hand, when steel became the dominant product, it was claimed by many that wrought iron is merely a dirty low-carbon steel instead of a product in which the

slag serves a definite and useful purpose! In many instances, these differences in opinion are due to the fact that corrosion is a phenomenon in which a great complexity of factors takes part. A slight change in the conditions may reverse the results.

Comparative Corrosion Resistance in Atmosphere

That the purity claimed for wrought iron is not a determining factor in its excellent corrosion resistance has been indicated by many investigators. Karl Daeves, in seven-year corrosion tests at Düsseldorf, Germany (reported in *Stahl und Eisen* in 1939, p. 710), found that iron of exceptionally high purity corroded more than basic bessemer steel, when exposed to air or buried in the ground. J. C. Hudson, reporting in his book "The Corrosion of Iron and Steel" the tests by the corrosion committee of the Iron and Steel Institute and the British Iron and Steel Federation, also states that Swedish wrought iron, a grade considerably

purier than British (Staffordshire) wrought iron and containing very little slag, corroded much more than mild steel after exposure to atmospheric corrosion at Sheffield for five years. Exposures of similar duration at Dove Holes Tunnel and at Calshot, England, are noted in Table I.

Hudson also reports one-year exposure tests in Sheffield atmosphere on mild steel, Staffordshire wrought iron, and wrought iron made by the Aston process in the United States. The ratings given in Table II are on the same relative scale as in Table I (mild steel rated as 100). The Staffordshire wrought iron corroded the least and Aston wrought iron corroded the most, with mild steel occupying an intermediate position.

The outstanding fact that emerges from the tests made

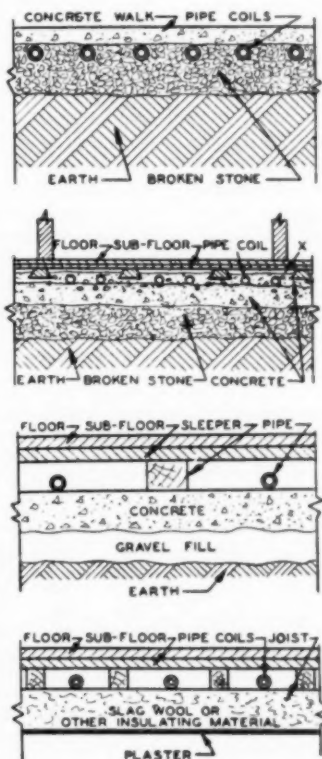


Fig. 1—Typical Methods of Floor Construction in Radiant Heating Installations. (A. T. Napier, "Radiant Heating", The Industrial Press, 1947)

by the British investigators is that there are marked differences in the corrosion behavior of different types of wrought iron, and that these differences are often greater than those observed between the two classes of material, mild steel and wrought iron. It is also of interest to note that the purest wrought iron obtainable, which happens to be of Swedish origin, is appreciably more corrodible than mild steel or the English wrought irons with their high slag and high phosphorus contents.

Summarizing results of recorded data on atmospheric corrosion of wrought iron and steel,

Table II — Atmospheric Corrosion in One Year of Wrought Irons and Mild Steel at Sheffield

MATERIAL	SURFACE CONDITION	
	AS ROLLED	SANDBLASTED
Mild steel*	100	100
Staffordshire wrought iron	67	75
Aston wrought iron, rolled in the U.S.A.	99	114
Aston wrought iron, rerolled in England	109	118

*See footnote to Table I.

F. N. Speller states in his book "Corrosion, Causes and Prevention" that wrought iron seems to have an advantage over mild steel in country atmospheres; in industrial atmospheres, however, steel containing more than 0.15% copper is more durable than wrought iron carrying the same amount of copper and that such copper-bearing steel is decidedly more durable than ordinary wrought iron (which generally carries less than 0.03% copper).

Table I — Atmospheric Corrosion of Steel Versus Wrought Iron; Five-Year Exposure in the As-Rolled Condition

MATERIAL	CALSHOT	DOVE HOLES TUNNEL	SHEFFIELD
Mild steel*	100	100	100
Swedish wrought iron	—	98	155
Staffordshire wrought iron	113	79	77

*The figures denote relative corrosion, with the mild steel rated as 100. Higher numbers indicate a higher rate of corrosion.

External Corrosion of Buried Pipe

Numerous examples of buried wrought-iron pipes that have successfully resisted corrosion for a great many years are cited in technical references. In considering these examples, ample allowance should be made for the well-established fact that there is a great variability in the corrosion resistance of various lots of wrought iron, and that the best of the old wrought iron has been preserved while the poorer has perished and was replaced.

The most carefully conducted corrosion tests on ferrous pipes buried in various soils are those by K. H. Logan of the National Bureau of Standards, published in the Bureau's *Journal of Research* in 1939, 1942 and 1944. Tests were started in 1922, and five years of exposure in a few soils showed no real difference in corrosion resistance of steel and wrought iron. In 1932 a large number of pipes were buried in various locations in the United States. At two-year intervals, some were dug up and corrosion evaluated by loss of weight and depth of pitting. (These tests are still in progress.)

The location of the various sites where the pipes were buried, the characteristics of the respective soils, and the composition of water extracted from these soils are shown in Table III.

Table III — Properties of Soils at Sites of Soil Corrosion Tests

TYPE OF SOIL	LOCATION	ANNUAL PRECIPITATION, IN.	AIR-PORE SPACE, %	COMPOSITION OF WATER EXTRACT*					
				pH	Na+K	Ca	Mg	Cl	SO ₄
Cecil clay loam	Atlanta, Ga.	48.3	18.2	4.6	—	—	—	—	—
Lake Charles clay	El Vista, Texas	49.0	5.0	7.1	3.12	0.69	0.47	1.59	3.04
Muck	New Orleans, La.	57.4	22.4	4.0	2.03	2.23	1.29	0.47	2.54
Peat	Plymouth, Ohio	37.0	33.2	2.6	2.91	10.95	2.86	0.0	56.70
Susquehanna clay	Meridian, Miss.	53.0	14.9	4.1	—	—	—	—	—
Tidal marsh	Charleston, S. C.	45.2	19.5	2.9	33.6	6.85	4.00	12.70	36.60
Docas clay	Cholame Flats, Calif.	16.0	4.7	8.3	28.10	2.29	0.76	28.80	0.26
Chino clay loam	Wilmington, Calif.	15.2	15.8	7.2	7.65	12.40	2.20	6.05	16.90
Mohave sand loam	Phoenix, Arizona	7.8	20.1	8.7	6.55	0.51	0.18	2.77	2.97
Cinders	Milwaukee, Wis.	30.1	—	8.0	0.77	3.03	0.53	0.08	2.89

*Milligram equivalent per 100 g. of soil.

The column with the heading pH indicates the degree of acidity or alkalinity of the various soils; a pH of 7 denotes a chemically neutral soil, lower pH numbers indicate an increasing degree of acidity, while pH numbers above 7 indicate an increasing degree of alkalinity. Measurements on pipes buried in these locations for five and nine years are summarized in Table IV. Loss in weight suffered through rusting is noted in roman numerals, while maximum depth of pits (in mils) formed during the test period is given in *italic* numerals.

The surface conditions of six varieties of pipes buried for nine years in Susquehanna clay at Meridian, Miss. (pH = 4.1), are illustrated in Fig. 2. The low-carbon steel is identified as N, while the two wrought iron pipes are marked A and B; the rest of the pipes are alloy steels. It is quite evident that, in this environment, the low-carbon steel pipe compares very favorably in appearance with the wrought iron pipes. This is corroborated in Table IV, where it is shown that the maximum depths of pits on the two grades of wrought iron pipes, after 9-yr. exposure in Susquehanna clay, were 72 and 101 mils, respectively, while for mild steel pipes it was 87. In the same test, the loss in weight on the wrought iron pipes was 7.80 and 9.38 oz. per sq.ft., while the steel pipe lost 6.65 oz. in 9 yr.

In this particular soil, the steel therefore occupied an intermediate position between the two grades of iron, as measured by the maximum depth of pits, and was slightly more resistant

Technical data indicate that wrought iron and steel do not differ materially in their behavior under corrosive conditions in the soil, concrete, and other environments surrounding radiant heating panels. Differences in corrosion resistance of various wrought irons are often greater than between steel and wrought iron. In highly corrosive soils the service life of either is very short. In other environments, either one or the other may prove somewhat superior, but claims of consistent superiority are not supported by facts.

to corrosion than either lot of wrought iron, if measured by loss of weight.

In other soils results varied, depending on the type of soil, but there was no consistent difference between the corrosion of the wrought iron and the steel pipes. Of the two methods of measuring corrosion, the depth of pitting is by far more important than the loss of weight, because when a pipe is punctured in service it requires replacing, regardless of its loss of weight. The outstanding feature indicated in the extensive Bureau of Standards' tests, summarized so briefly here, is the great variation in the corrosion ability of various soils. All pipes were punctured in five years when buried

Table IV — Corrosion and Pitting in Various Soils (Logan)

Rate of corrosion (in roman numerals) in oz. per sq.ft. 1 oz. per sq.ft. = 0.0015 in. penetration. Maximum depth of pits (in *italic* numerals) in mils. *Indicates that one or more specimens were completely punctured

SOIL	WROUGHT IRON A		WROUGHT IRON B		LOW-CARBON STEEL	
	5 YEARS	9 YEARS	5 YEARS	9 YEARS	5 YEARS	9 YEARS
Cecil clay loam	0.48, 64	3.72, 50	0.54, 71	3.70, 73	0.55, 50	4.09, 59
Lake Charles clay	1.99, 66	22.83, 96	1.39, 65	19.54, 106*	2.56, 71	28.76, 154*
Muck	1.77, 68	12.57, 118	1.80, 64	12.68, 116	2.03, 103	16.24, 110
Peat	1.20, 38	14.26, 55	1.30, 37	16.48, 64	2.09, 24	16.72, 27
Susquehanna clay	0.74, 54	7.80, 72	0.73, 56	9.38, 101	0.86, 66	6.65, 87
Tidal marsh	0.55, 22	8.52, 100	0.44, 37	4.24, 55	0.82, 36	9.03, 54
Docas clay	4.23, 129	D 120*	4.42, 110	D 145*	4.85, 154*	D 154*
Chino silt loam	1.41, 91	13.60, 102*	1.38, 87	11.44, 110	1.95, 74	12.86, 112
Mohave sand loam	1.94, 85	5.82, 88	2.15, 106	9.99, 130*	2.86, 154*	18.56, 154*
Cinders	6.04, 145*	D 145*	4.73, 145*	D 145*	6.50, 119*	D 154*

D means specimens completely destroyed by corrosion.

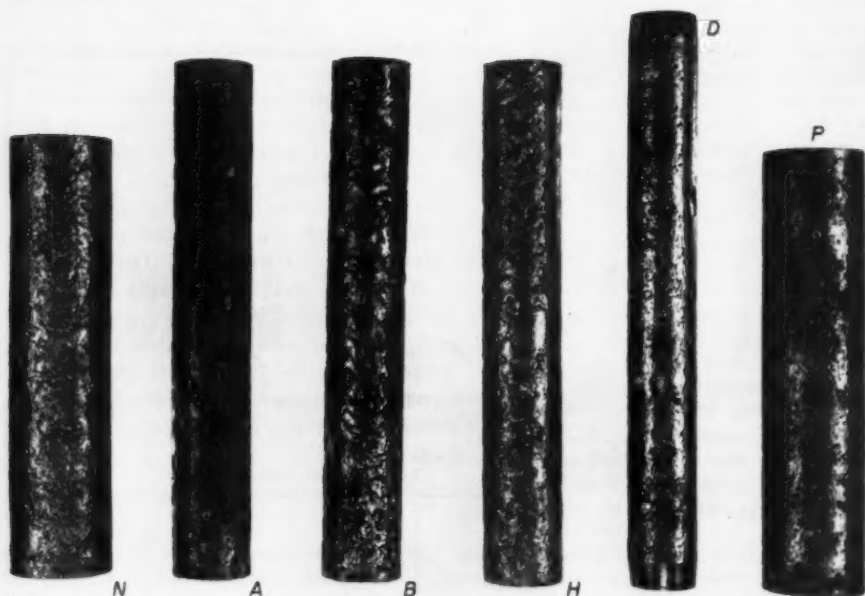


Fig. 2 — Wrought Iron and Steel Pipe Buried Nine Years in Susquehanna Clay at Meridian, Miss.

N, Low-carbon tube; A, Hand puddled wrought iron; B, Machine puddled wrought iron; H, Copper-molybdenum openhearth iron; D, Nickel-copper steel; P, 5% chromium steel

in cinders; on the other hand, in most of the soils the rate of corrosion was very low. As a general statement it may be said that, in acid soils (pH under 7), the steel pipes were corroded less than the wrought iron pipes, and the reverse appears to be true of alkaline soils.

In Speller's book are several comparisons of wrought iron and steel pipes which have been in service together underground for many years—for example, wrought iron couplings on steel pipe in an Indiana soil for 15 years. The couplings and the pipe corroded at about the same rate.

In checking over records of many cases where claims were made for superior corrosion resistance of wrought iron, Howe and Stoughton noted two items of interest:

1. In many instances where pipes have been in service for many years, the steel was of inferior quality because it was made at a time when steelmaking was in its infancy. Chemical controls had not yet been introduced, specifications were lacking, and, in many instances, the carbon and sulphur contents of the steel were very much higher than the present limits for this grade.

2. Previous to 1912, wrought iron and steel pipe were not clearly identified by manufacturers. Pipe purchased as wrought iron frequently turned out to be steel, and the two have been quite frequently mixed in service. This is corroborated by Speller who, in his investigations covering many years, found over 100 water lines in which wrought iron and steel were accidentally coupled together in the same piping system. In such cases, both materials have been in use under identical conditions for many years. Typical data on such steam and water lines are in Table V. (Measurements were made an inch or so from each end of the pipe, to eliminate the contact effect between dissimilar metals.) On the whole, Speller's figures do not show any marked difference between the performance of wrought iron and steel pipes.

In 1924, the American Gas Association queried the large companies in the United States: "What is the relative life of steel and wrought iron pipe laid under average conditions?" Replies were received from 17 companies, based on opinions and experience without presenting actual data. The majority expressed the opinion that wrought iron pipe will outlive steel pipe.

Table V — Relative Corrosion of Mixed Wrought Iron and Steel Pipe Carrying Steam and Water (Speller)

LOCATION OF LINE	AGE OF PIPE IN SERVICE	NUMBER OF PIECES	CHARACTER OF SERVICE	MAXIMUM PITTING	
				IRON	STEEL
Frick Coke Co. power plants Cresson, Pa. (coal field)	6 months to 8 yr.	21 lots; 26 pieces w.i., 26 steel	Boiler feed water lines	0.112 in.	0.108 in.
	7 months to 10 yr.	9 pieces w.i., 9 steel	Hot water lines Cold water lines Hot and cold water	0.107 0.057 0.100	0.092 0.048 0.085
Allegheny General Hospital, Pittsburgh	7 to 8 yr.	42 pieces w.i., 27 steel	Hot water supply	0.105	0.105
A New York hotel	6 to 10 yr.	9 pieces w.i., 9 steel	Hot water and steam return line	0.095	0.067

In summarizing the replies in *Proceedings* of the Technical Section, A.G.A., 1924, the Committee pointed out that, on account of the many variables, opinions based on casual observations are apt to be erroneous, particularly with respect to soil corrosion. That this fact is recognized by large users, where more weight is given to over-all economic considerations, is evident from answers given to another question in the same questionnaire: "What material do you use for service pipe?" Of 31 companies replying to this question, 21, or 67.8%, used steel; six, or 19.4%, used wrought iron; and four, or 12.8%, used both materials.

As far as corrosion of buried wrought iron and steel pipe is concerned, the present level of our knowledge supports the conclusion drawn by one of the largest American gas companies (quoted by Speller): "Many tests have been made of actual conditions in the field, and it has been the general opinion that both kinds of pipe showed almost the same loss of weight by corrosion, the tendency toward pitting being somewhat less in steel."

Corrosion by Concrete

There are few quantitative data available on the relative corrosion of wrought iron and steel pipe in concrete; however, it is generally known that there is very little corrosion, because the free lime content of concrete protects ferrous materials. Known cases of corrosion have always been traced either to badly mixed concrete or to excessive quantity of chlorides in it. Hudson describes two examples in his book "The Corrosion of Iron and Steel":

1. In 1937, a serious case of corrosion occurred in the steel pipes of a sprinkler system in a large department store. They were buried in a 4-in. brick-concrete layer over a reinforced

concrete floor; the pipes were 1 in. in diameter and were under 100-psi. pressure. Corrosion was reported in only one block of the store, where the concrete had been made with a brick aggregate containing up to 2% calcium sulphate. The floor was covered with asphalt before the concrete dried; consequently, the concrete had probably been maintained in a moist condition. In other blocks of the same building a pumice aggregate, practically free from sulphate, had been used for the concrete, and this had been allowed to dry out before being covered with asphalt. No corrosion trouble was experienced in these blocks.

2. Corrosion of wrought iron girders embedded in the reinforced concrete roof of a basement. The extent of the corrosion was such that the floor girders could be easily punctured by the tools used to break away the concrete during the examination. The aggregate used for the concrete was a typical, low-grade coke breeze. This was the prime cause of corrosion. Under modern practice, such a filler would not be used.

Excepting such cases as those cited, which would not be tolerated in modern practice, ample evidence supports the statement that concrete made of cement, sand, and gravel in proper proportions practically assures freedom from corrosion of either wrought iron or steel. Chlorides may be present in concrete whenever salt water has access to foundations, or if (during erection in cold weather) salt or calcium chloride has been added to the mixture to prevent freezing. Either condition is highly undesirable; under such unfavorable conditions, neither material will prove immune to rusting. Stray electric currents also enhance corrosion with no particular preference for either wrought iron or steel.

In view of the above facts, it may be of interest to review some accelerated corrosion tests carried out by Swinden and Stevenson and

reported in Hudson's book, p. 227. Materials were subjected to intermittent sprays while suspended from a traveling belt. In the course of a complete revolution of the belt, which takes 6 min., the specimens were subjected to the following treatments:

1. Sprayed during passage through the first chamber.

2. The specimens then enter a metal box ventilated at the top and bottom and heated to about 100° F. In 45 sec. they are dried completely without being heated appreciably.

3. The specimens then travel back to the spraying chamber.

Such treatment was continued for four weeks. Each day the specimens were subjected to 60 complete cycles (approximately 7 hr.). Each morning the specimens were doused with distilled water and allowed to dry thoroughly before spraying was commenced. At the end of the test, the rust was removed by a special solution, and loss in weight was measured.

Results for two different sprays are given in Table VI. For comparison, results of atmospheric corrosion during one year's exposure at Stocksbridge, England, are also shown. The order of merit of the four materials under atmospheric corrosion and the two spray tests was practically identical; the Staffordshire wrought iron displayed the highest resistance to corrosion on all tests, the mild steel rated a close second, while the Aston-Byers and Swedish wrought iron rated third and fourth.

While accelerated corrosion tests should be accepted with caution, those listed in Table VI carry some weight because they have shown an excellent correlation with field tests of longer duration. They indicate that there is no great difference between corrosion of steel and wrought iron in a saline or acid environment.

Corrosion by Hot Water and Steam

Speller's data in Table V, for a number of applications where wrought iron and steel pipes were used in the same steam and water lines, show that there was no material difference in depth of pitting. A similar investigation was made by W. H. Walker ("The Relative Corrosion of Iron and Steel Pipe as Found in Service", *Journal, New England Water Works Assoc.*, 1912, Vol. 26, p. 7). He found 64 instances where

wrought iron and steel pipe had been installed together in hot water, cold water, and steam lines. Following is a summary of the performance records of these materials after varying lengths of service:

In 18 installations steel pipe corroded more than wrought iron; in 20 installations the opposite was true; in nine cases there was considerable corrosion on both materials with no significant difference between them; in 17 installations corrosion was negligible in both materials. Walker concluded that "taken on the average, there is no difference in the corrosion of wrought iron and steel pipe".

An interesting comparison was also reported by Speller. Alternate lengths of 2-in. uncoated

Table VI—Correlation of Atmospheric Corrosion and Intermittent Spray (Hudson)*

MATERIAL	FIELD TEST (1 Yr.)	SPRAY A† 4 WEEKS	SPRAY B‡ 4 WEEKS
Mild steel	100	100	100
Staffordshire wrought iron	96	97	96
Aston-Byers wrought iron	111	112	133
Swedish wrought iron	129	110	159

*The figures denote relative corrosion, with mild steel rated as 100. Higher numbers indicate a higher corrosion rate.

†0.25% sulphuric acid.

‡0.06% sodium chloride and 0.05% sulphuric acid.

wrought iron and steel pipe were used in an ammonia condenser at a blast furnace plant. Cooling water flowed over them almost continuously for 11 years. The coils were then taken apart, cleaned, and inspected. There was no appreciable difference; no corrosion whatever was found inside where ammonia circulated and—while there was considerable rusting of the outside surface—no leaks developed in either the wrought iron or in the steel. The maximum depth of pitting was 0.055 in. on steel, and 0.054 in. on wrought iron.

In another program of tests reported by Speller, alternate lengths of wrought iron and steel pipe were used in hot water, steam return, and vent lines in various cities. The actual number of installations tested was 85; durations ranged from 12 months to 12 years. No consistent difference in corrosion resistance was clearly indicated. On the average, the maximum depth of pitting was somewhat smaller on the steel pipe, but the number of pits was slightly greater. It is thus reasonable to conclude that, for hot water and steam lines, the performance of steel pipe compares favorably with that of wrought iron.

ELECTROMET *Data Sheet*

A Digest of the Production, Properties, and Uses of Steels and Other Metals

Published by Electro Metallurgical Company, a Division of Union Carbide and Carbon Corporation, 30 East 42nd Street, New York 17, N. Y. • In Canada: Electro Metallurgical Company of Canada, Limited, Welland, Ontario

MANGANESE . . . Deoxidizer and Toughener for Steel

Manganese is one of the most important alloys used in making steel. It is practically indispensable as a deoxidizer and cleanser for improving the hot-working properties of steels. When used as an alloying element, it makes steel stronger and tougher and it is therefore an important constituent of many structural and engineering steels.

Deoxidizes and Cleans Steel

The effectiveness of manganese in deoxidizing steel was first recognized in 1856, when it was used in the Bessemer process of steelmaking to counteract the bad effects of sulphur. In fact, manganese made this process a commercial success. Today, manganese is used as a deoxidizer and cleanser in the production of nearly all grades of open-hearth and electric-furnace steel, as well as high-grade cast iron.

Research work carried out recently in ELECTROMET's laboratories at Niagara Falls, New York, has provided new and important information on the value of manganese as a deoxidizer. This work shows that manganese is a more effective deoxidizer than has been previously realized; and that a combination alloy of silicon and manganese is a much stronger deoxidizer than either silicon or manganese by itself. Complete information is given in a report entitled "Solubility of Oxygen in Liquid Iron Containing Silicon and Manganese." If you would like a copy of this report, free of charge, write to the address above.

Improves Hot-Working Properties

By combining readily with sulphur, manganese performs another valuable job, it removes the principal cause of hot-shortness or brittleness—thereby giving steel better rolling and forging properties. In this reaction, the manganese combines with the sulphur to form manganese sulphide, as follows:



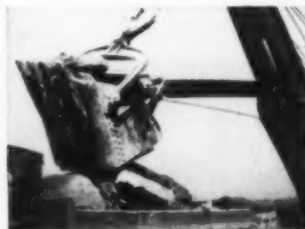
The manganese sulphide remaining in the steel is a less harmful type of inclusion than the iron sulphide would be, the hot-working properties of the steel are improved.

The weakening and embrittling tendencies of sulphur in cast iron can also be counteracted by the addition of manganese to the cupola charge.

Increases Strength, Toughness, and Wear-Resistance

When used as an alloying element in steel, manganese produces a steel with greater strength and toughness, and there is no serious loss of ductility. Additions of about 13 per cent manganese produce the well-known Hadfield manganese steel. High-manganese steels have exceptional resistance to wear; and consequently they have many applications in engineering jobs. Instead of wearing away quickly under conditions combining severe pressure, shock, and abrasion, these steels actually become harder through use. Thus, they last longer.

Because of the tendency of high-manganese steels to work-harden, they serve industry in important and varied applications. Manganese steel castings, for example, are used for railroad frogs and crossings, rock-crusher parts, steam-shovel dipper



Dipper bucket teeth, cast of Hadfield manganese steel, actually increase in hardness under abrasive wear from gravel and rock in construction work — thus last many times longer than those of ordinary steel.

teeth, and dredge-bucket lips. The chief applications of manganese steel are in rails used for special service, and light forgings subjected to heavy wear.

ELECTROMET Alloys

Manganese is produced by ELECTROMET in forms suitable for practically every use of the iron, steel, and non-ferrous metal industry. Some of the ELECTROMET products are listed below. For a complete description of these alloys, write for a copy of the 100-page booklet, "ELECTROMET Ferro-Alloys and Metals."

The terms "EM" and "Electromet" are registered trade-marks of Union Carbide and Carbon Corporation.

Alloys of Manganese and Their Uses

Standard Ferromanganese	The product most commonly used for adding manganese to steel for the purpose of alloying or deoxidizing and cleansing.
Low-Carbon Ferromanganese	For adding manganese to steels having a low carbon content, such as stainless steels of the 18 per cent chromium, 8 per cent nickel type.
Medium-Carbon Ferromanganese	Commonly used for making manganese steel containing 1.50 to 2.00 per cent manganese, and in the production of Hadfield manganese steel.
Low-Iron Ferromanganese	For applications in the nickel, aluminum, and copper industries where a low-iron alloy is required.
Silicomanganese	Used by the steel industry as a furnace block; as a deoxidizer; and also for manganese additions, particularly in the production of engineering steels containing 0.10 to 0.50 per cent carbon.
"EM" Silicomanganese Briquets	For adding manganese (with silicon) to cast iron in the cupola.
"EM" Ferromanganese Briquets	For adding manganese (without silicon) to cast iron in the cupola.

Personal Mention



Herbert J. French

Since 1929, when Herbert French joined the staff of International Nickel Co., he promoted the industrial uses of alloy steels so successfully that he was quickly put in charge of the company's developmental work on alloy steels. In 1943 he was made assistant manager of the development and research division, and since 1947 has been vice-president of the company. It is no exaggeration to say that his success has been due to the high regard in which he is held by American metallurgists both in the steel producing and consuming industries, regard for his integrity and for his encyclopedic knowledge. The citation awarding him the Distinguished Service Award for meritorious contributions to progress in engineering alloy steels is but one evidence of these facts.

French is one of that generation of young engineers who got mixed up in the production of war material in World War I. He was fortunate enough to be working with airplane engines, for which nothing but the best would do. At

war's end he joined the National Bureau of Standards, and for ten years studied such fundamentals as the quenching operation, the effect of various alloys on steels, and the properties of various alloy constructional steels under extreme conditions. His writings during those years established his reputation as a man who could cut through the underbrush straight to the central core of fact. This ability came in good stead during his service in Washington during World War II as chief of the metallurgical branch of the steel division, War Production Board, and later as assistant director for raw materials and facilities.



Robert F. Mehl

Robert F. Mehl, director of the metals research laboratory and head of the department of metallurgical engineering at Carnegie Institute of Technology, has been granted leave of absence to head the Metallurgical Advisory Board, recently established by the National Research Council. Before joining the Carnegie faculty in 1932, Dr. Mehl was superintendent of the division of physical metallurgy in the Naval Research Lab-

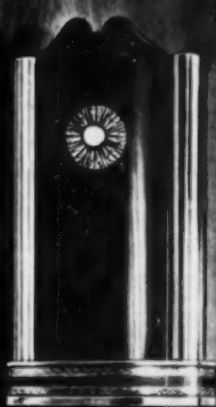
oratory in Washington, and later assistant director of the American Rolling Mill Co. research laboratories in Middletown, Ohio. He has received three honorary degrees: Doctor of Science from Franklin and Marshall, Doctor of Engineering from Stevens Institute of Technology, and a Doctor Honoris Causa from the Universidade de Sao Paulo in Brazil. He is an author of many papers on physical metallurgy and the science of metals. During World War II, Dr. Mehl served in the U. S. Embassy in London with the simulated rank of brigadier general.



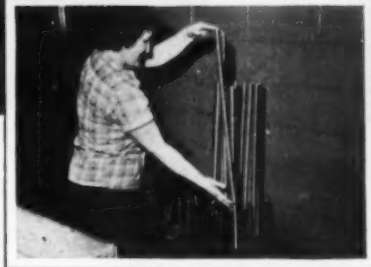
Bruce W. Gonser

Bruce W. Gonser has been named assistant director of a new program dealing with the less common metals at Battelle Memorial Institute, Columbus, Ohio. Dr. Gonser, a member of the Battelle staff since 1934, will guide development of an enlarged program in unexplored fields of metallurgy and the chemistry of metals as well as continue to direct research in nonferrous metallurgy. Dr. Gonser is known for his contributions to the technology of rare metals. He is American manager of the Tin Research Institute, chairman of the Rare Metals Committee of the Electrochemical Society and is active in work of the American Society for Metals and the American Society for Testing Materials. His outstanding contribution to metallurgical science has been in the developing of techniques for forming pure metals and metallic coatings, including chromizing, silicizing, and stannizing.

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Personals

J. A. Steele is a member of the product engineering section of the Cathode Ray Tube Div., General Electric Co., Syracuse, N. Y.

Alex Eckstein has been promoted from assistant plant metallurgist to plant metallurgist of the Continental Foundry & Machine Co., Warwood Works, Warwood, W. Va.

R. K. Lee, formerly manager of the research department for Alloy Rods Co., York, Pa., has been elected vice-president in charge of research and engineering by the company.

William B. Klee, Jr. is now president of Vacuum Melt, Inc., Greenville, Pa., a new company manufacturing stainless steel tubing.

John J. Daly, Jr. is section chief of the test pack section in the research department of Continental Can Co., Inc., Chicago.

C. C. Pingree is secretary and purchasing agent for Whitmore Oxygen Co., Salt Lake City.

Victor D. Smith has been promoted to department metallurgist for the sheet mill of the Torrance works of the Columbia Steel Co., Torrance, Calif.

Nathan D. Gady has accepted a position as metallurgist at the U. S. Bureau of Mines, Central Experimental Station, Pittsburgh.

Howard E. Hartner, formerly with the combustion department at Jones and Laughlin Steel Corp., is now working for Hitchiner Mfg. Co., Manchester, N. H., as assistant metallurgist.

Irwin M. Hymes, formerly at the New York University research laboratory, has accepted a position with International Business Machines Corp., Poughkeepsie, N. Y., as laboratory technician.

Andrew J. Kocak has been employed as assistant plant metallurgist at the Warwood plant of the Continental Foundry and Machinery Co., Wheeling, W. Va., since his graduation from the University of Pittsburgh in June.

Albert H. Wilson is now working as an inside salesman in the alloy and stainless department of Joseph T. Ryerson & Son, Inc., Pittsburgh.

Since his graduation from University of Rochester in June, **Isadore Caplan** has been employed by the Samuel Greenfield Co., Inc., Buffalo, N. Y., as a metallurgical engineer.

R. K. Warren has been appointed assistant manager of tool-steel sales of the Crucible Steel Co. of America. He will make his headquarters in the Sanderson-Halcomb Works, Syracuse, N. Y.

William C. Spencer, Jr. has been appointed product manager of the Horace T. Potts Co., steel warehouse distributors in Philadelphia and Baltimore.

Raymond J. Thomas, past-chairman of the Lehigh Valley Chapter of American Society for Metals, has been appointed superintendent of heat treating and plating in addition to his duties as chief metallurgist at Jacobs Aircraft Engine Co., Pottstown, Pa.

Ben B. Gracier is now plant manager at Hurst Industries, San Jose, Calif.

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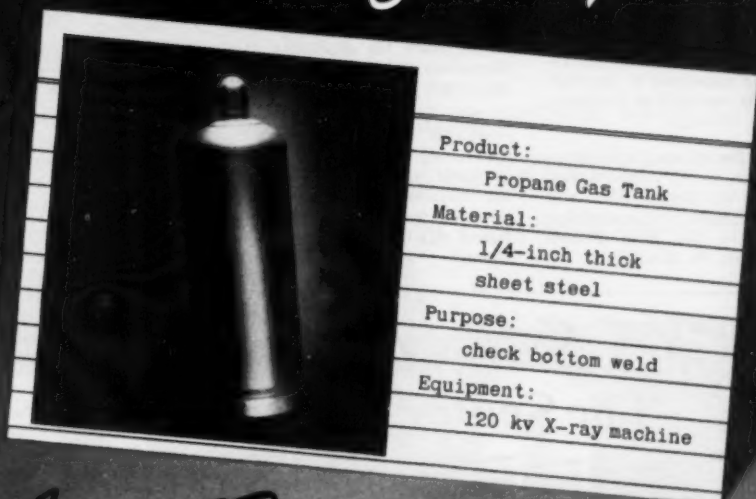
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Personals

Wayne R. Rawlings ☼ has recently been appointed to the staff of materials research at Continental Can Co., Chicago.

R. D. Fuller ☼, after graduation from a nine months' guided missile course in August 1950, was assigned to head the propulsion laboratory of the First Guided Missile Group, Ft. Bliss, Tex.

A. J. Martini ☼ has been employed as a research metallurgist in the Atomic Power Div., Westinghouse Electric Corp., Pittsburgh, since his graduation from Rensselaer Polytechnic Institute in June 1950.

John A. Disantis, Jr., ☼ is now employed at F. G. Wade, Inc., Cleveland, in the engineering department. He will be assigned to the metallurgical department as soon as production at the company's newly acquired foundry is started.

Walter A. Zimmerman ☼ has been appointed district manager for the Columbia Tool Steel Co., Cincinnati, and will have charge of the toolsteel warehouse and office. Mr. Zimmerman replaces James Terry ☼ who has resigned.

Frank W. Davis ☼ has just received an appointment as metallurgical engineer in the division of reactor development, U. S. Atomic Energy Commission, Washington, D. C.

William Pollack ☼ is employed as a product engineer by Sylvania Electric Products Inc., Towanda, Pa., in the tungsten and chemical division. He graduated from Polytechnic Institute of Brooklyn in June of 1950.

C. S. Barrett ☼ has been awarded the recently authorized Mathewson Medal of the American Institute of Mining and Metallurgical Engineers in recognition of his paper "Faults in the Structure of Copper-Silicon Alloys" as the most notable written contribution to metallurgical science in the three-year period preceding the granting of the award. The paper was published in the *Journal of Metals*, January 1950.

John H. Port ☼ has been in the research laboratory of Chase Brass and Copper Co., Waterbury, Conn., as a research assistant, since his graduation from Lafayette College in June 1950.

Roy F. Hancock ☼ has been appointed assistant to the vice-president in charge of sales for the Vanadium Corp. of America, New York. Prior to this appointment Mr. Hancock was associated with the Carnegie-Illinois Steel Corp., Pittsburgh, as manager of eastern alloy steel sales.

Richard Huttinger ☼ has been with the metallurgical department of the Alan Wood Steel Co., Conshohocken, Pa., since his graduation from Temple University in June 1950.

William B. Blair ☼ has been employed by the Westinghouse Corp., Meadville, Pa., as a design engineer since his graduation from Grove City College in June 1950.

Robert L. Haynes ☼ is now metallurgical engineer in the metallurgy department of the Institute of Plumbing Research, American Radiator and Standard Sanitary Corp., Louisville, Ky.



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"Good Housekeeping" in the Hardening Room at HY-PRO!

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Vertical model for long, slender drills, reamers, broaches, etc.

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For small tools, cutters of moly, tungsten and cobalt high speed steels.

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to our High-Vanadium series
of super high speed steels

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E. V. M.
Neatro
Van Cut

VAN CUT makes its bow as a star in our well-known high-vanadium group of high speed steels, with these standout advantages: while outperforming most high speed steels, VAN CUT can be ground with ordinary shop techniques—and, VAN CUT is not subject to tungsten limitations. • You can grind VAN CUT in almost any shape for almost every type of cutting tool, especially broaches, milling cutters, form tools, etc.

Try VAN CUT on your next exacting job!

Vanadium-Alloys Steel Co.

First Quality Tool Steels

LATROBE, PENNA.

COLONIAL STEEL DIVISION...ANCHOR DRAWN STEEL CO.

Personals

Robert R. Penman has been working as a foundry trainee with Ford Motor Co., Dearborn, Mich., since his graduation from Missouri School of Mines in July 1950.

Stuart Smith has been transferred from the Louisville, Ky., office and made regional general manager of the Reynolds Metals Co., St. Louis.

John Birtalan has been employed by Timken Roller Bearing Co., Canton, Ohio, since his graduation from Fenn College in May 1950.

Jesse C. Little has accepted a position as technical director of Preformed Line Products Co., Cleveland. He will be in charge of the company's research and development of transmission line and communication line accessories. He formerly was with American Steel & Wire Co. in charge of the vibration fatigue laboratory.

Mitchell Silverstein has been elected chairman of the board of directors of Specialloy, Inc., Chicago. He has resigned as president and director of Silverstein & Pinof, Inc., Chicago.

After graduating from Pennsylvania State in June, **Robert T. Anderson, Jr.** went to work for the Aluminum Co. of America, Pittsburgh, as a sales engineer.

F. R. Morral, recently associate professor of materials engineering at Syracuse University, now heads the X-ray diffraction department of Kaiser Aluminum & Chemical Corp., Spokane, Wash.

Vernon Pryer has been employed as a development engineer with United States Graphite Co., Saginaw, Mich., since his graduation from University of Michigan in June.

Joseph Mazia, formerly chief of rustproofing division of the American Paint Co., Ambler, Pa., has recently entered business for himself as consulting engineer with offices in Washington, D. C.

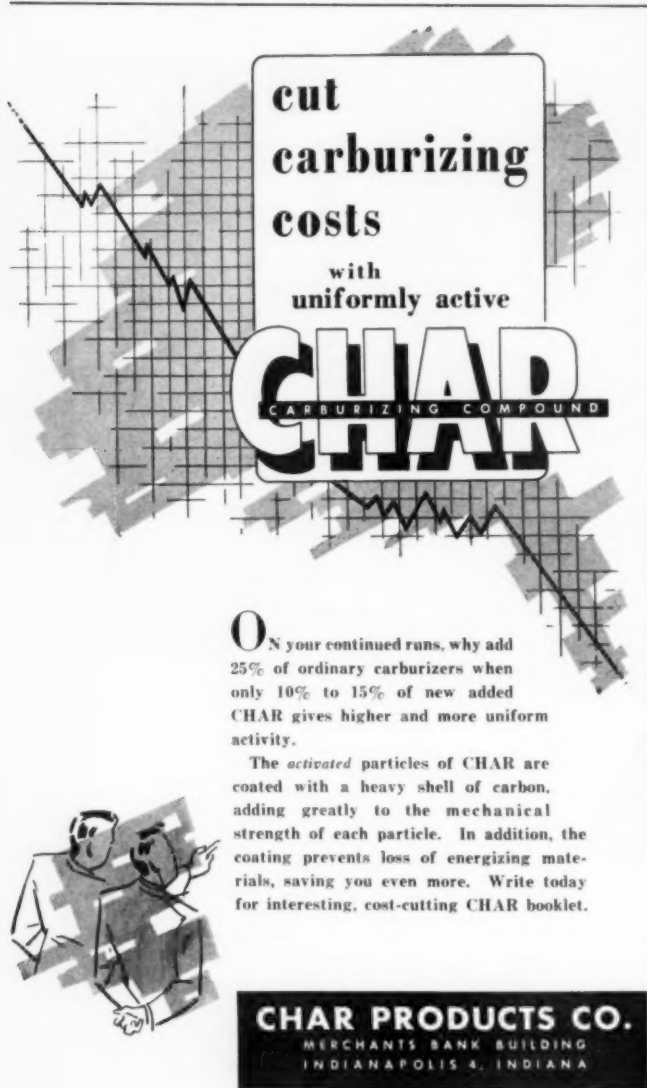
Since his graduation from Missouri School of Mines & Metallurgy in January 1951, **Robert B. Barrow** has been employed by Bausch & Lomb Optical Co., Rochester, N. Y., as a metallurgist in the frame division.

Burton C. Haworth has recently accepted a position as engineer in the engineering materials group of the Engineering Service Div., E. I. du Pont de Nemours & Co., Wilmington, Del. He was formerly employed as a field engineer with the Haynes Stellite Div., Union Carbide & Carbon Corp., New York.

C. Canfield Clark has been employed at the International Nickel Research Laboratory, Bayonne, N. J., since his graduation from Rensselaer Polytechnic Institute in January 1950.

R. J. Kuehl is now in the casting department of the new electrolytic copper refinery of Kennecott Copper Corp., Garfield, Utah.

R. W. Sandelin, formerly chief metallurgist at Stockholm Valves and Fittings, Birmingham, Ala., is now chief metallurgist and in charge of electric furnace steel melting operations at Connors Steel Co., Inc., Birmingham, Ala., a division of H. K. Porter Co., Inc.



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On your continued runs, why add 25% of ordinary carburizers when only 10% to 15% of new added CHAR gives higher and more uniform activity.

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HEVI-DUTY FURNACE *Plus* *Electronik* CONTROL



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The need for flexibility with economical, uniform production is making increased demands upon heat-treating equipment and instrumentation.

Such a combination is found in the plant of Utica Drop Forge & Tool Corporation at Utica, New York. Here, savings are made through the teamwork of Hevi-Duty vertical retort carburizing and nitriding furnaces and recording *Electronik* controllers. Protection for furnaces and work is provided by Brown excess temperature cut-offs. Typical of the flexibility and quality made possible by such equipment is the ease with which production is changed from pliers and wrenches to turbine and compressor blades.

Multiple-zone temperature control plus the use of controlled atmospheres permits extremely precise regulation of heats. Such dependable performance is being repeated by *Electronik* indicating and recording controllers throughout the metals industry . . . delivering top-quality, economical production.

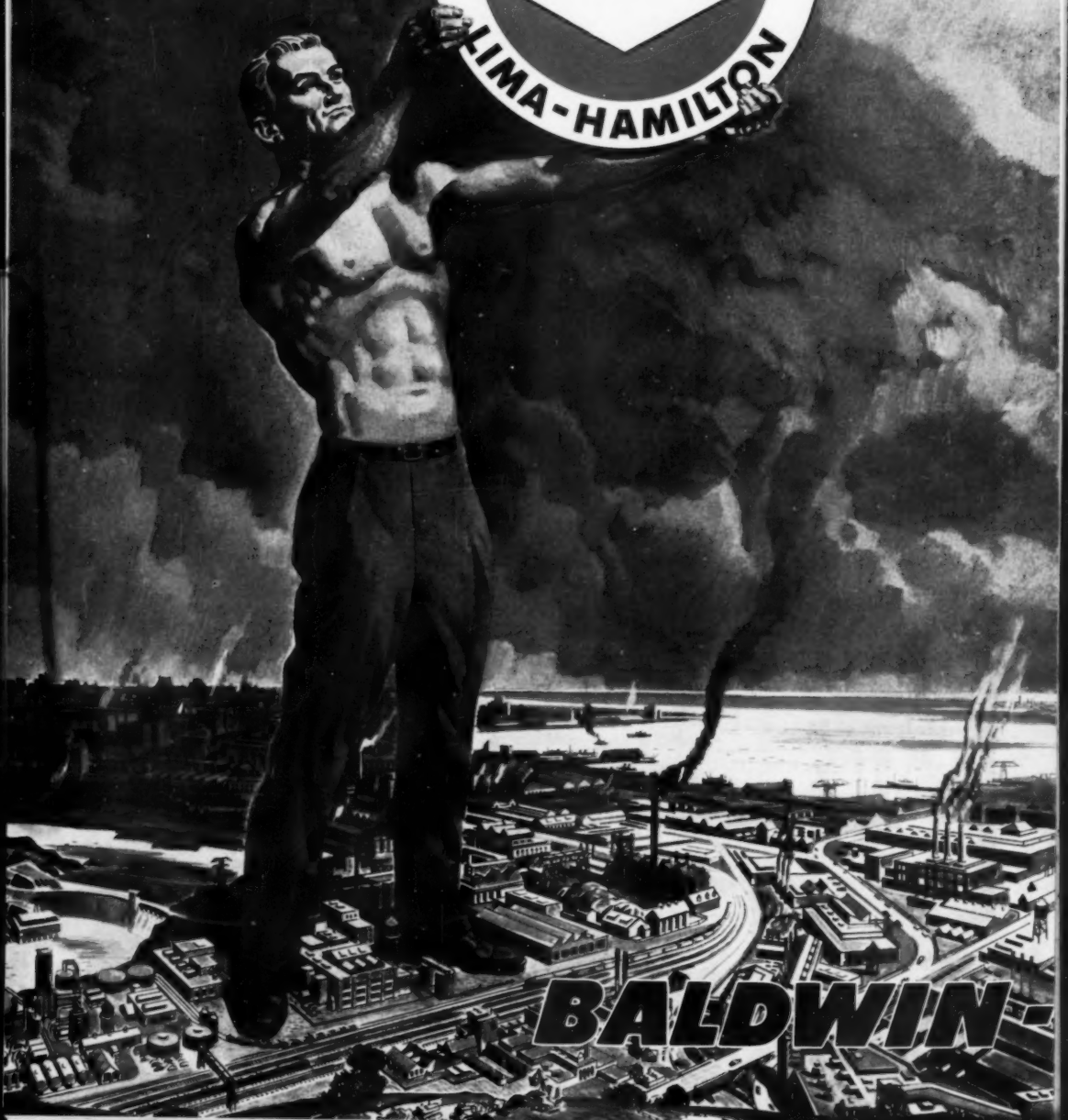
Call in your local Honeywell engineer for a discussion of your utilization of *Electronik* control . . . he is as near as your phone!

MINNEAPOLIS-HONEYWELL REGULATOR Co., Industrial Division, 4503 Wayne Ave., Philadelphia 44, Pa. Offices in more than 80 principal cities of the United States, Canada and throughout the world.

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Symbol of Service to Industry

Representing the combined facilities of two of America's leading suppliers of industrial machinery and equipment, this new Baldwin-Lima-Hamilton symbol is backed by many decades of experience, a progressive and continuing research program, and the most modern engineering and manufacturing techniques. It represents the activities of eight plants spotted from coast to coast and numerous established sales outlets, strategically located for prompt, competent service.

The dispersion of B-L-H manufacturing facilities permits "local" handling and delivery

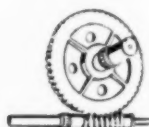
on many items to the important producing areas. It also conforms to the projected pattern for better national defense.

You have undoubtedly used many of the products offered by Baldwin, by Lima-Hamilton and by various subsidiaries, but you may not know, today, how well the Baldwin-Lima-Hamilton Corporation is equipped to supply your needs.

This array of products will suggest added opportunities for you to benefit from the expanded production-distribution-service facilities Baldwin-Lima-Hamilton now offers.



STEEL FORGINGS—Hammered and pressed steel forgings—rolled rings and flanges.



NON-FERROUS—brass and bronze alloy castings for heavy duty service.



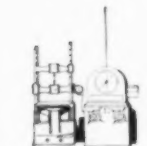
HYDRAULIC PRESSES—All types and capacities. Complete standard line.



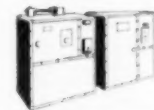
POWER TOOLS—Bending rolls for plate fabricators and ship yards.



PLATE PLANERS—With design features to maintain accuracy, increase capacity.



TESTING MACHINES AND INSTRUMENTS—Universal, Fatigue, Stress Analysis.



FATIGUE MACHINES—A complete range of sizes, for simulated service testing.



STRAIN GAGES AND INSTRUMENTS—For an accurate picture of stress distribution.



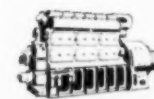
CRANES—Full range of capacities up to 110 tons, crawler and rubber mounted.



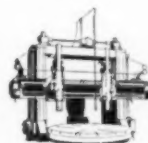
SHOVELS—Capacities from 1/2 yd. to 6 yd. Design features increase output.



DRAGLINES—Available in variable capacities for economical earth-moving performance.



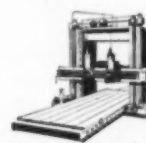
DIESEL ENGINES—For stationary and marine applications.



BORING MILLS—100" to 43' swing, with mechanical, electronic or hydraulic controls.



HEAVY DUTY LATHES—Line includes 40" to 168" engine lathes, or larger.

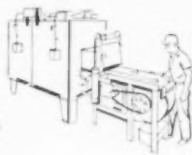
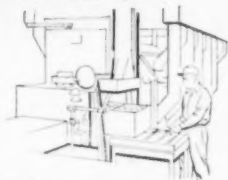


PLANERS—Standard models from 84" to 15'. Latest controls, every modern feature.

Baldwin-Lima-Hamilton Corporation, Philadelphia 42, Pennsylvania. **Plants:** Eddystone and Burnham, Pa.; Lima, Hamilton and Middletown, Ohio; Rochelle, Illinois; Greenwich, Connecticut; San Francisco, California. **Offices:** Chicago, Cleveland, Houston, New York, Philadelphia, Pittsburgh, San Francisco, St. Louis, Washington

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There's a Westinghouse Furnace to provide the exact answer for every heat-treating application, gas or electric:

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J-10361



YOU CAN BE SURE... IF IT'S

Westinghouse

HEAT-
TREATING
FURNACES

Personals

Gilbert Soler has resigned as vice-president, manufacturing operations, and director of Atlas Steels Ltd., Welland, Ont.

John A. Michelson, who received his degree from Ohio State University in June 1950, is now working for Thompson Products, Inc., Cleveland.

Edward D. Weisert, formerly sales engineer attached to the Chicago district office of the Haynes Stellite Div., Union Carbide and Carbon Corp., has been transferred to the research department in Kokomo, Ind., where he is a metallurgist.

John C. Barrett is deputy chief of the metals branch of the Industrial Division of the Military Security Board, Coblenz, Germany.

John Milos, formerly with Central Iron & Steel Co., Harrisburg, Pa., has been appointed general manager of Phoenix Iron & Steel Co., Phoenixville, Pa.

L. G. Graper, superintendent of steel production for Wisconsin Steel Works, a division of International Harvester Co., has recently been appointed technical advisor for the Lone Star Steel Co., Dallas, Tex.

Bruce S. Old has been elected vice-president of Arthur D. Little, Inc., consulting research and engineering firm of Boston. Dr. Old has been in charge of process metallurgy for his company since 1946, and a director since 1949. During the war he was head of the U. S. Navy's sections on guided missiles and on metallurgy and materials, and later was consultant in metallurgy for the U. S. Atomic Energy Commission.

Richard Rimbach and **Armand T. Gaudreau** have announced the organization of a new consultant management engineering firm, Gaudreau, Rimbach & Associates, with offices in Pittsburgh, Chicago, New York and Washington. The firm will specialize in plant layout, warehouse planning, material handling and production control.

J. P. Watry of Aluminum Casting and Engineering Co., Milwaukee, has been elected chairman of the foundry division of the Aluminum Association.

"dag" Colloidal Graphite Lubricates where Ordinary Lubricants Fail

At temperatures below zero, and up to 5000° F. in inert atmospheres, "dag" colloidal graphite is a lubricant that does not gum up . . . that defies break-down . . . that fights friction constantly. Easy to apply, too, by spray or brush.

"Dag" colloidal graphite is electric-furnace graphite specially processed by Acheson to make its particles microscopic in size, and far more slippery and durable than conventional petroleum lubricants. It is dispersed in a variety of organic and inorganic carriers for positive transmission to the zone of heat and for effective concentration there.

"Dag" colloidal graphite is available in dispersions designed to lubricate under all conditions of deep piercing, forging, stretch-forming, wire-drawing and ingot stripping . . . to assist in the parting of castings . . . to permanently lubricate moving parts that may be subject to extremely high or low temperatures . . . and in degreasing solutions which destroy ordinary lubricants.

More data on the advantages of "dag" colloidal graphite lubrication in metal-working operations is contained in a recent bulletin. Write for your free copy of Bulletin No. 426-10C.

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DISPERSED

**Acheson Colloids
Corporation**

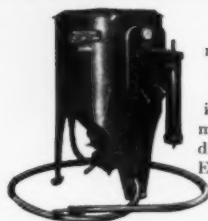
Port Huron, Mich.

...also Acheson Colloids Limited, London, England

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**BIG
NEWS**

on Blast Cleaning Dust Control Precision Finishing

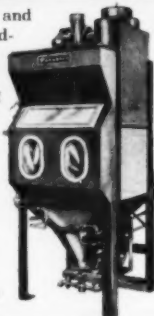
**Blast Cleaning Unit
is PORTABLE!**



Ideal for maintenance and many other jobs, including removal of rust, dirt, scale, etc. Economically cleans large objects like tanks, bridges, structural work before painting. Six sizes, stationary or portable, from \$170.00 and up

**Hydro-Finish
SPEEDS POLISHING!**

Removes scale, and directional grinding lines . . . prepares surfaces for plating and holds tolerances to .0001"! Liquid blast reduces costly hand cleaning and finishing of molds, dies, tools, etc. Models from \$1295.00 and up



**STOP DUST
at the SOURCE!**



Pangborn industrial type Unit Dust Collectors trap dust at source. Machine wear is minimized, housekeeping and maintenance costs reduced. Solves many grinding and polishing nuisances and material losses. Models from \$286.00 and up

**COMPACT Blast Cabinet
for SMALL WORK!**

Ideal for producing smooth, clean surfaces on pieces up to 60" x 36" in size. Cleans metal parts, removes rust, scale, grime, dirt, paint, etc., in a few seconds. Saves money all year 'round. Models from \$315.00 up



Look to Pangborn for the latest developments in Blast Cleaning and Dust Control Equipment

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PANGBORN CORP., 1800 Pangborn Blvd., Hagerstown, Md.
Gentlemen: Please send me more information on the equipment I've checked at the left.

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Personals

Wayne B. Miller ☼ has resigned his position as metallurgist at the New York works of Avildsen Tools and Machines, Inc., to become chief metallurgist for Tinnerman Products, Inc., Cleveland.

William S. Dritt ☼, formerly plant metallurgist at Technical Metal Processing, Inc., is now a metallurgist with Union Carbide & Carbon Corp., Oak Ridge, Tenn.

John H. McCullough ☼ has been employed in the engineering department of Renabie Gold Mines, Ltd., Renabie, Ont., since his graduation from the University of Toronto in June.

James B. Stein ☼ has been assigned the position of chief of the organization and methods branch of the Arnold Engineering Development Center, Tullahoma, Tenn.

Robert B. Neal ☼ has been employed as a junior metallurgist at the K-25 Plant, Union Carbide & Carbon Corp., Oak Ridge, Tenn., since his graduation from the University of Kentucky in November.

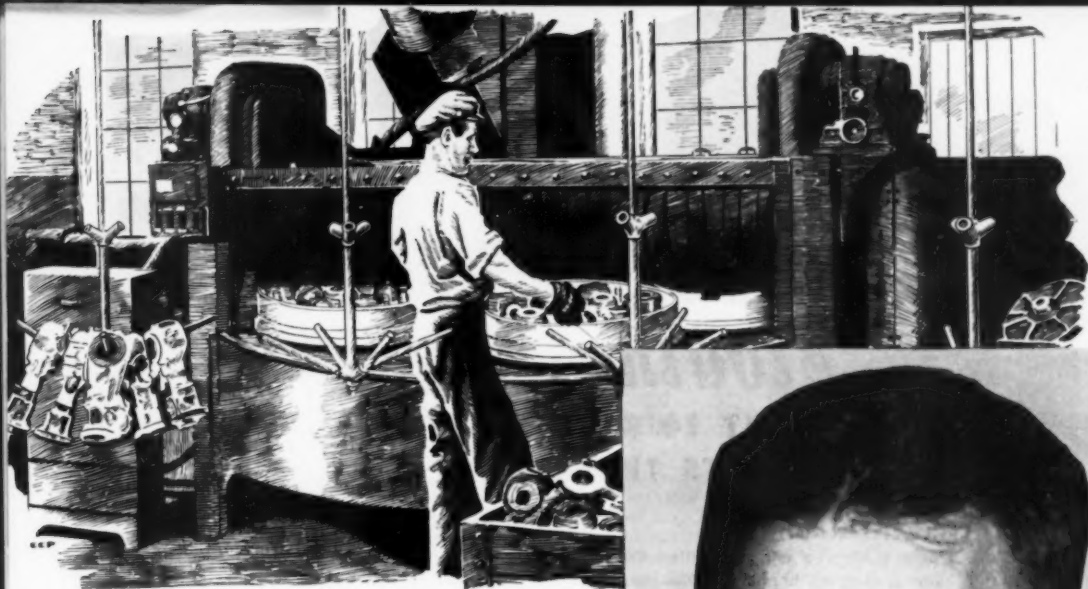
Sidney D. Tannenbaum ☼ is now employed as a metallurgical technician at the manufacturing research department of International Harvester Co., in its Chicago laboratories.

Lawrence J. Chockie ☼, formerly with the quality control group of the Gates Rubber Co., Denver, is now with the radio-metallurgy section of General Electric Hanford Works, Richland, Wash.

George E. Farnham ☼ has been employed as a metallurgical engineer by Dow Chemical Co., Midland, Mich., since his graduation from University of Michigan in June 1950.

Roger Sutton ☼, formerly consulting metallurgist for General Alloys Co. and senior associate of Roger Sutton Associates, is now senior metallurgist at the Argonne National Laboratory, Chicago, Ill.

Charles E. Harvey ☼, formerly consulting spectrographer for Allied Research Laboratories, has opened the American Spectrographic Laboratories, San Francisco, for consulting, analysis, and spectrographic research.



ROTOBLAST^{*} Ends Cleaning Room DOWN-TIME

at Fairbanks, Morse

PANGBORN ROTOBLAST pays off at the Freeport Works of Fairbanks, Morse with *no work stoppages* in the cleaning room. As M. F. Putz, Foundry Superintendent puts it: "ROTOBLAST gives us good service with nominal repair. We like it!"

And the record backs him up. Castings with hard-to-clean pockets are cleaned down to virgin metal . . . with tiny cracks and imperfections exposed, which saves time on inspection time and rejects. One man plus the ROTOBLAST Table and Barrel handles the entire cleaning load (25,000 pounds of small castings) per 8-hour day!

ROTOBLAST can save you money on blast cleaning. *Look to Pangborn for the latest developments in blast cleaning and dust control equipment.*

More than 25,000 Pangborn Machines Serving Industry

Pangborn

^{*}Trademark of the Pangborn Corporation



BLAST CLEANS CHEAPER

with the right equipment for every job



M. F. Putz, Foundry Superintendent of Fairbanks, Morse

Here's the Key to Low-Cost, High-Quality Blast Cleaning

Pangborn ROTOBLAST saves from \$5000 a year to \$50,000 a year. Specifically, ROTOBLAST builds savings these five ways . . .

SAVES LABOR: One ROTOBLAST machine and operator can do as much as, or more than, a two-man crew and old-fashioned equipment.

SAVES SPACE: In many cases, one ROTOBLAST machine replaces five or more old-fashioned machines.

SAVES TIME: Cases on record prove ROTOBLAST can cut cleaning time up to 95.8%.

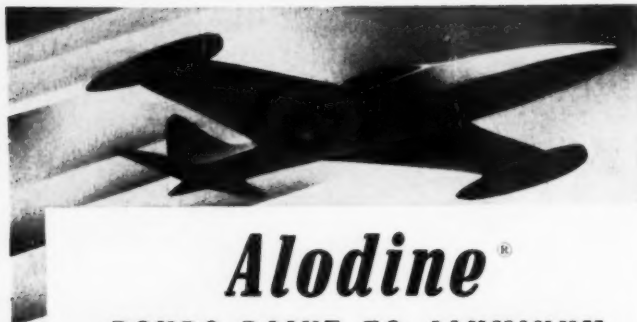
SAVES POWER: Modern ROTOBLAST uses but 15-20 h.p. compared to 120 h.p. needed by old-fashioned equipment.

SAVES TOOLS: On work cleaned with ROTOBLAST, cutting tools last up to 2/3 longer because no scale is left to dull edges.

SEND FOR FREE BULLETIN!

All ROTOBLAST machines are covered in Bulletin 214. Write for your free copy to Pangborn Corporation, 1800 Pangborn Blvd., Hagerstown, Md.





Alodine®

BONDS PAINT TO ALUMINUM AND PROTECTS THE METAL

EASY TO USE

Process is foolproof and chemical solution can be applied by dipping, spraying, brushing or flow-coating.

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Alodizing is a chemical conversion process.

ECONOMICAL

Low chemical cost, short coating time and low temperature keep overhead down.

EFFECTIVE

The tough, durable Alodized surface makes paint stick to aluminum and resists corrosion. "Alodine" meets these Service specifications: MIL-C-5541; MIL-S-5002; AN-E-19; AN-F-20.

Brush Alodine®

Brush "Alodine" is easily and quickly applied to assembled aircraft in the field, shop, or hangar. Cleaning and coating chemicals for Brush Alodizing are shipped in bulk or in the convenient Brush "Alodine" Chemical Kit No. 1. This Kit contains enough chemicals to treat about 1000 square feet of surface and is an ideal package for use at airfields of commercial airlines or of the Armed Services anywhere.

**Use "Alodine" and
Alodized Aluminum
for Maximum
Product and Finish
Durability!**

Write for Descriptive Folder.

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AMERICAN CHEMICAL PAINT COMPANY

AMBLER, PA.

Manufacturers of METALLURGICAL, AGRICULTURAL and PHARMACEUTICAL CHEMICALS



Personals

Jesse Oatman Betterton, Jr., has been appointed to the staff of the metallurgical division of the Union Carbide and Carbon Corp.'s Oak Ridge National Laboratory.

N. H. Balaam, formerly northern California district sales manager for Kaiser Steel Corp., has been transferred to Washington, D. C., to manage the company's recently opened offices there.

Ben Kaul, formerly chief tool and die engineer for the Warren division, has been appointed technical development engineer by the Mullins Manufacturing Corp., Salem and Warren, Ohio.

Robert N. Hooker has accepted a position as materials and process engineer with Douglas Aircraft Co., Santa Monica, Calif. He formerly was with the Studebaker Corp., South Bend, Ind.

George Evans has taken a position as foreman with Wilson Foundry & Machine Co., Pontiac, Mich. He graduated from University of Michigan in February.

Norman Glaskin, formerly in General Electric Co.'s Thompson laboratory, is now in the Air Force Procurement Field Office, Army Base, Boston, as materials and processes inspector.

Ellis L. Foster, Jr., graduated from University of Kentucky in January 1950 and has been employed at Battelle Memorial Institute, Columbus, Ohio, as a research engineer since that time.

Clyde W. Petrie has been employed in the product control section of the research department, Chase Brass & Copper Co., Waterbury, Conn., since his graduation from Rensselaer Polytechnic Institute in June 1950.

Auzville Jackson, Jr., is now employed as a patent examiner with the U. S. Patent Office, Washington, D. C.

Recent additions to the materials division, engineering research department, Standard Oil Co. of Indiana, include **James K. Stanley** as senior project engineer, **C. Robert Lillie** as project engineer, and **Price B. Burgess** as research engineer in the physical metallurgy group.

Tool Steel Topics



BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation, Los Angeles.



150,000 Stainless Spoons from Striking Dies of XX Carbon

The shaping of stainless steel can be a tricky job. A leading cutlery maker, faced with new problems in starting the production of stainless flatware, asked Bethlehem to recommend a tool steel suitable for striking dies. (The master dies are hand-engraved by craftsmen in the traditional fashion of this intricate art.)

The manufacturer adopted our recommendation of Bethlehem XX Carbon Tool Steel for this difficult operation. Results have been highly satisfactory. Spoons and other flatware are struck in quantities exceeding 150,000 pieces

from one impression of the striking dies.

XX Carbon Tool Steel offers many advantages for general-purpose tools and dies. It's easy to machine and heat-treat; it develops a hard case, reinforced by a tough, shock-resisting core; it holds a keen cutting edge; it's economical; and there's a range of carbon content to meet many different requirements.

We fully control the hardenability of this grade, and give it a careful and uniform spheroidize-anneal. Bethlehem Carbon Tool Steels are the kind you can rely on for top performance.

Our Tool Steel Engineer Says:



Use thermocouple when you pack-harden tools

Whenever tools are pack-hardened (to reduce the scaling and decarburization) place a thermocouple in the pack against the tools so that the time the tools are at heat can be determined accurately.

Recently a 34-in.-diameter die ring of our Lehigh H (high-carbon, high-chromium) Tool Steel was pack-hardened by an experienced heat-treater. Treatment completed, he checked the hardness and was flabbergasted to find that he had obtained a hardness of only Rockwell C-48. Then he checked his pyrometer charts which proved, he thought, that he had followed the recommended heating cycle. Why the low hardness?

A Bethlehem trouble-shooter suggested that he insert a thermocouple in the pack against the ring. He did so, and this time got a hardness of Rockwell C-60—proving that in the first treatment the die ring wasn't heated long enough to reach the proper temperature, even though the records of the furnace heating cycle appeared to indicate correct treatment.

BIG DIE OF A-H5 MAKES CAR PARTS

A massive die produces spring plates from 3/16-in. steel plate for hopper cars, at the Berwick, Pa., plant of American Car & Foundry. All wearing surfaces of the die, which performs a punching, blanking, and forming operation, are made of A-H5 Tool Steel.

This leading car-builder uses this 5-pet-chromium, air-hardening tool steel to produce car parts from carbon steel, low-alloy high-tensile steel, and aluminum. A.C.F.'s experience with A-H5 confirms its good machinability, its high resistance to wear and distortion, and its sharp, durable cutting edges.

Here's a general-purpose, air-hardening grade of steel that's hard to beat when safer hardening and high wear-resistance are of special importance.



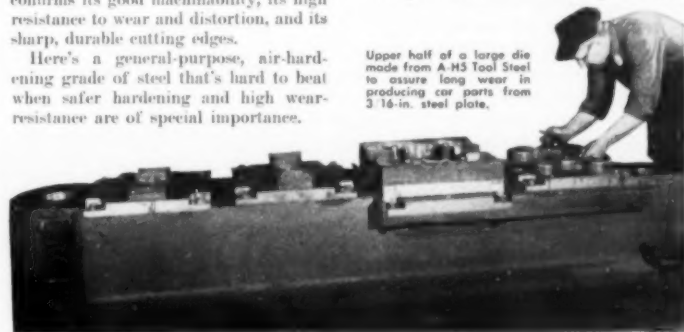
Prompt shipment to our distributors is made possible by our modern tool-steel depot at Bethlehem, Pa. Complete sizes of 23 different grades are stocked.

Tool Steel Distributors Give Service in a Hurry

Delivering tool steel in a hurry is only one of the many services performed by the distributor. He knows local requirements, and he carries large stocks of the tool steel grades and sizes that his customers are most likely to require. He's ready at any time to go into action to see that your tool steel needs are taken care of, whether it means cutting bars to exact size or lending a hand in recommending the kind of heat-treatment you'll need.

Having a tool-steel distributor in your neighborhood makes it unnecessary for you to carry large inventories of tool steel . . . and he often carries other steel specialties that you use frequently.

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Tool Steel

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For more detailed information, write to



Corrections to Product Index

The following additions should be made in the product listings published as a part of the January issue of *Metal Progress*:

Under *Ammonia, Anhydrous*; add Barrett Division, Allied Chemical & Dye Corp.

Under *Steel, Cold Drawn and Steel, Tool*; add A. Milne & Co.

Under *Cement, Refractory*; add Lummite Division, Universal Atlas Cement Co.

Add Foxboro Co. under *Charts, Combustion Controls, Furnace Controls, Instruments (Recording), Meters (Gas or Air), and Pyrometer Tubes*.

Add International Nickel Co. under *Alloys (Heat and Corrosion Resistant), Castings (Centrifugal), Castings (Corrosion and Heat Resisting), Castings (Precision Investment), Cast Iron (Welding Rods), Electrodes (Welding, Coated), Heating Elements (Radiant Tube), Pipe (Corrosion Resistant), Plates, Rods (Welding), Tubes (Nonferrous), Tubing (Seamless Mechanical), and Welding Rods and Fluxes*.

Steels for Plastic Molds*

THE more frequently utilized analyses are those that are case hardened; however, in special applications both the oil hardening nondeforming type and the hardenable stainless grades are employed for injection dies.

Dies to be carburized after hubbing are soft carbon steels; the type with 0.10% vanadium is preferred to retain a fine-grained case. Such steels are utilized where mold design is simple, together with medium molding pressures, small-to-medium sized cavities, and medium length production runs.

If high excessive pressures are required, such as compression molding of hard thermosetting materials, the cavity may sink; where machining operations are required to supplement the hubbing, the excessive softness of the material may produce a gummy chip, as well as large tool markings. (Cont. on p. 403)

*Abstract of "The Plastic Mold Steels—Their Selection and Treatment", by Lester F. Spencer, *The Tool Engineer*, November 1950, p. 20.

DESPATCH *CF* FURNACES

Designed to fit today's heat processing needs



A GREAT AID FOR TESTING PRODUCTION IN...
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DESPATCH CF Furnaces are specifically designed to meet the most rigid research and production requirements. New streamlined models will complement other modern laboratory or production equipment ... available in either 850° F. maximum temperature or 1250° F. maximum temperature. Consider these outstanding performance features:

ACCURATE TEMPERATURE CONTROL—Tolerances to $\pm 2\frac{1}{2}^{\circ}$ F.

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- UNIFORM
- FAST
- VERSATILE
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EIGHT SIZES TO CHOOSE FROM

Available in either electric or gas models

No.	INSIDE DIMENSIONS, INCHES			Max. Temp.
	Width	Length	Height	
CF-10	13	13	13	850° F.
CF-18	19	19	19	850° F.
CF-26	37	19	25	850° F.
CF-32	37	25	37	850° F.
CF-9	13	13	13	1250° F.
CF-17	19	19	19	1250° F.
CF-25	37	19	25	1250° F.
CF-31	37	25	37	1250° F.

DESPATCH also engineers and manufactures a complete line of conveyorized and batch or pot type furnaces (to 1250° F.)



Battery of DT (Pot Type) Gas Fired Furnaces used to heat heat 20 in. shell cases.



Battery of Dispatch Reducers for heating aluminum castings.

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BILLETS AND FORGINGS FOR PRODUCTION, TOOL ROOM AND MAINTENANCE REQUIREMENTS

Steels for Plastic Molds

(Starts on p. 402) Although it is possible to stone such tool marks out, the resulting polishing costs for obtaining a high luster would be greatly increased.

A characteristic feature is that such low-carbon steels can be obtained with a maximum Brinell hardness of 90 (Rockwell B-55) in the annealed condition; and therefore cold hubbing can often be accomplished in one operation. If high hardness in the die is required, a water quench is necessary on unalloyed steels; excessive size changes are likely. In annealed low-carbon steels, however, it is easy to hub deep cavities, as for fountain pen bodies, 0.45 in. diameter and 3% in. deep, in a 40-ton press.

With the carburizing compositions that are hubbed with a relatively high polish, it is imperative that the finish be maintained throughout the entire fabricating process. If it is essential to interspace an anneal between hobbing operations, grease, oil and other foreign contamination should be removed from the mold. The die may be wrapped in brown paper prior either to pack annealing or pack carburizing to protect the surface from the abrading action of the packing material.

Where a die is completed in a single push, it may be advisable to strain anneal; this precaution will assure minimum warpage in subsequent heat treatment. On low-carbon compositions such as mentioned the annealing temperature is usually 1550 to 1600° F., followed by a furnace cool; a strain relief anneal would consist of a 1275° F. heat followed by a slow cool.

As the total alloy content increases, it is usually necessary to raise the temperature for strain relief. Parts should always be packed in clean cast iron chips.

Hubbing becomes more difficult in alloy die steels, and machine worked cavities are generally recommended. However, a 0.10% C steel with 2.30% Cr is supplied with Brinell 102 max., making it possible to hub intricate shapes. For example, a mold blank 1.75 in. in diameter by 2.25 in. in length was hubbed in one push using a load of 113 tons. The hub measured 0.910 in. in diameter, tapered 0.045 in. per in.; the depth of cavity obtained was 0.71 in. In the heat treated condition, such a steel exhibits great wear resistance and is recommended for long

production runs. The alloy is quite machinable.

A steel with 5% Cr and 0.90% Mo is a high-strength alloy that can be used with equal success on plastic molds and die casting dies. Its principal feature is that it retains its high strength characteristics at operating temperatures of at least 800° F. It can also be employed for severe molding conditions, but can be cold hubbed only to a limited extent. For strain relief anneal the temperature is 1400° F, followed by a slow cool. A full anneal at 1600° F, followed by a slow cool will give about 125 Brinell.

Where large dies and correspondingly higher mold pressures are encountered, a type containing 0.10% C, 0.40% Mn, 1.50% Cr and 3.50% Ni is useful for high wear resistance of the case, and sufficient core strength. The analyses are principally used for machined cavities.

Under conditions of extreme corrosion, such as in the injection molding of certain corrosive plastic materials, or in locations where high humidity will cause sweating, stainless Type 420 (13% Cr, 0.30% C) is utilized. Another advantage of this analysis is that it can be reworked. The material is usually obtained in the annealed condition, with hardness about 160 Brinell. Shallow cavities of simple design have been hubbed in it.

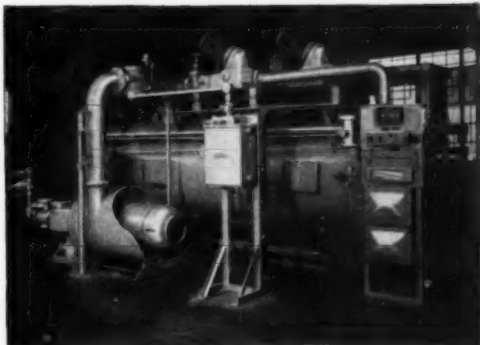
To obtain full corrosion resistance, it must be in the fully hardened condition. To obtain minimum size change, the material should be hardened from 1800 to 1900° F, followed by an air cool. The draw temperature is usually between 300 and 400° F. This treatment will produce Rockwell C-44 to 50. Greater hardness, with some sacrifice of accuracy, can be obtained by quenching in oil. The same draw temperature would apply.

Pure Iron

REPORTS of activities at National Physical Laboratory (Teddington, England) for the years 1948 and 1949 have just been printed, and it would appear that a major accomplishment of the Metallurgy Division (S. P. Allen, superintendent) has been the perfection of equipment and operations for the regular production of 25-lb. ingots of 99.96% iron and its alloys.

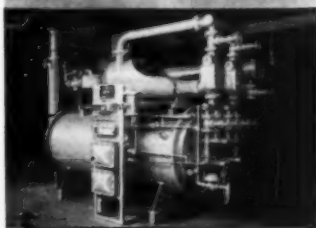
The report for 1948 notes that casting *in vacuo* had produced sound ingots with nonoxidized surfaces.

(Continued on p. 496)

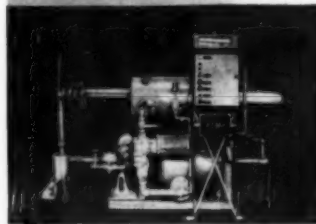


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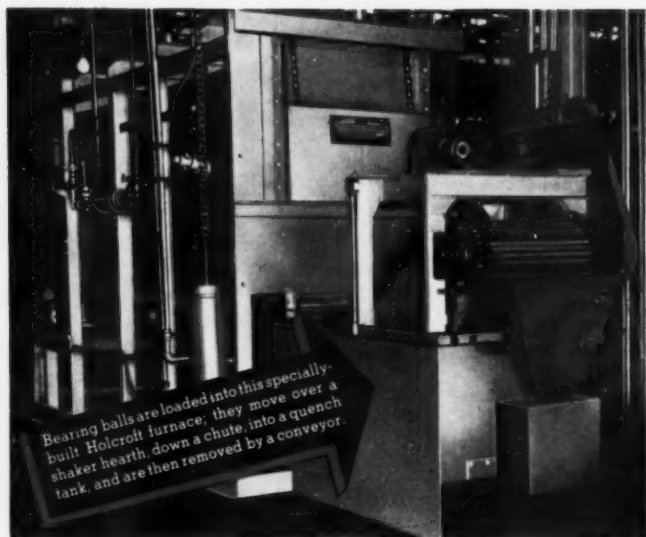
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Pure Iron

(Starts on p. 405)

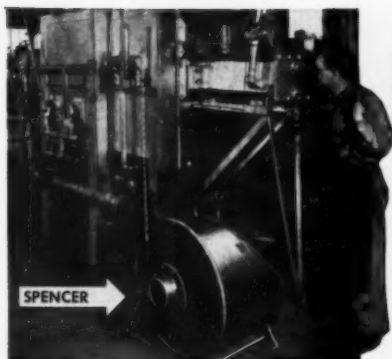
but the oxygen content of the metal was not yet sufficiently low.

By the end of 1949 these difficulties had been overcome and production reduced almost entirely to a matter of careful routine work. Ingots of pure iron, and of alloys with manganese, silicon, nickel, and chromium containing up to 5% of the added element, were made. The metal contains no individual impurity in amounts greater than 0.01%, and usually not greater than 0.005%. The process could readily be operated on a considerably larger scale, and it is thought that the way is now open for systematic examination of the properties of alloys of iron in a manner not previously possible.

Testing of the pure iron over a range of temperature extending from +200 to -196° C. (+392 to -310° F.) has begun. In material of this purity the transition from tough to brittle fracture in a notched-bar impact test occurs very sharply. For instance, a bar of pure iron will behave in a perfectly ductile manner at -14° C. (+6° F.) and in a brittle manner at -16° C. (+3° F.). In tensile tests, pure iron is ductile at -73° C. (-100° F.), but brittle at -186° C. (-300° F.). The effect of additions of manganese is complex. Additions up to 2% lower the transition temperature in a notched-bar impact test from -15° C. to about -50° C. (+5 to -60° F.) but addition of 5% manganese raises it to over 100° C. The behavior appears to be influenced by changes in the microstructure of the alloys and it is possible that the methods of rolling and heat treating may have important effects.

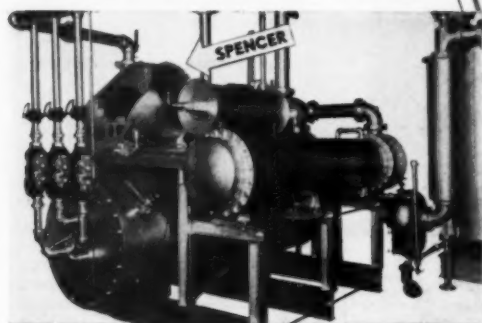
Dilatometric studies of the transformation from alpha to gamma in iron-nickel alloys have shown that the change can occur by two distinct processes, one of which is a very rapid process not involving diffusion, and the other is a nucleation-and-growth phenomenon. The experimental investigation of the free energy changes in these alloys has proved very helpful in suggesting mechanisms by which nucleation and growth could occur.

In the production of pure iron there has been a considerable increase in the amount of analytical work on the determination of trace impurities in iron. An improved method of determining aluminum, considered to give an accuracy of $\pm 0.0005\%$, has been developed.



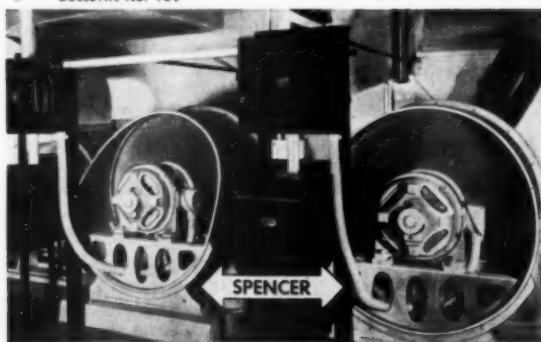
Heat Treating

BULLETIN No. 126



Gas Booster

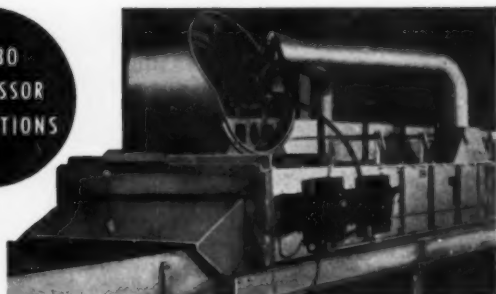
BULLETIN No. 109



Pneumatic Tube

BULLETIN No. 104

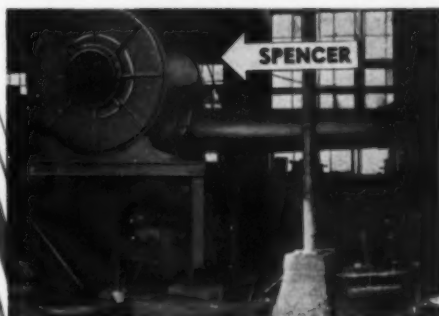
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Corrosion of Magnesium Alloys*

AMONG THE ALLOYS tested for the Navy's Bureau of Aeronautics were two developed by Dow Chemical Co. during the war. One is FS-1 alloy in the "H" condition (3% Al, 1% Zn, 0.3% Mn) clad with M1 alloy (1.5% Mn), and the other is Dow's ZK-60 (0.7% Zn, 0.07% Mn, 0.6% Zr). These turned out to be the best of those tested, when exposed to weather either at Washington, D. C., or at Hampton Roads, Va. Possibly due to gases from a near-by power plant chimney, the "urban" atmosphere at Washington generally produced earlier failure than the "seashore" exposure at Hampton Roads.

Small damage was done to *unstressed* specimen by two years' atmospheric exposure. For example, loss in tensile strength of bare, extruded ZK-60 was only 6% of its original 50,000 psi. "Threshold" stress of ZK-60, defined as the maximum stresses that materials can withstand without failure when continuously exposed to atmosphere in Washington or Hampton Roads for a fixed period of time, is about 18,000 psi. (no failure at this stress in 1010 days).

The clad FS-1h sheet, with original tensile strength of 42,000 psi., was the most resistant to stress corrosion. Specimens were exposed in the marine atmosphere, stressed to 30,000 psi. (90% of the yield strength) for 500 days without failure.

Among the bare alloys, the M1-h sheet was outstanding. After 1175 days of exposure at Washington under a stress of 16,000 psi. (55% of yield strength) the M1-h sheet alloy had not failed.

Of the alloys with aluminum as a major constituent (Dow FS-1, JS-1, J-1, and O-1) the susceptibility to stress corrosion in the weather increased with aluminum content up to about 6.5%. Extensive laboratory tests on alloys immersed in recommended solutions (either continuous or intermittent) indicated that continuous immersion in 0.01% NaCl solution gives the best agreement with weather exposure.

*Abstract of "Stress-Corrosion of Wrought Magnesium Base Alloys", by Hugh L. Logan and Harold Hession, Research Paper 2074, National Bureau of Standards.



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"IN THIS ONE SHOP we had to do a whole range of different metal cutting operations. We couldn't get full answers every time from general lubrication guides. Guesswork was a threat to production," the superintendent said, "so I finally called in a Cities Service Lubrication Engineer."... What happened is this:

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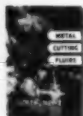
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Mechanism of Primary Creep*

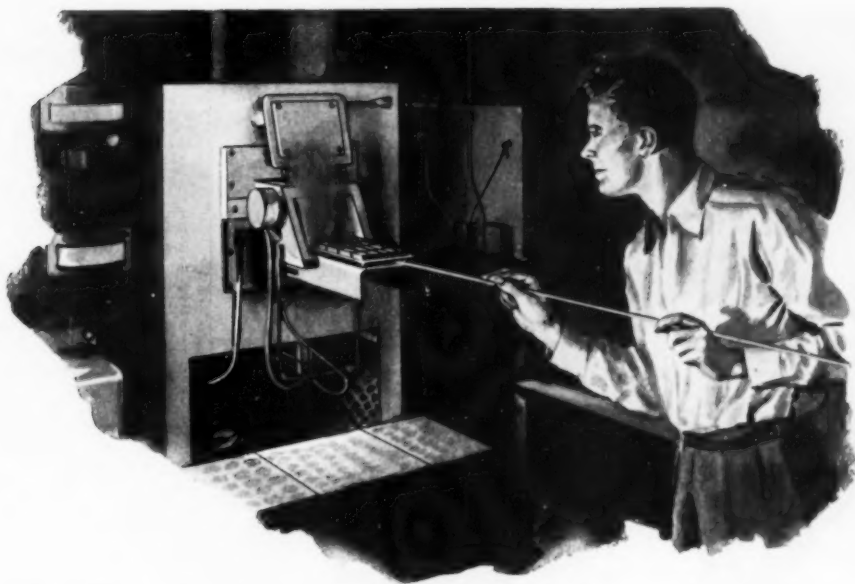
A STUDY was made of the mechanism of primary creep in polycrystalline, annealed, high-purity aluminum. Specimens were examined by X-ray diffraction and metallographic microscope as they were deformed progressively at various temperatures. Comparisons were made of the substructures thus formed with those developed by heating specimens previously cold worked.

In primary creep, the mode of breakdown of the grains into a substructure is determined by the rate of strain. At the lower rates, the dissociation of the grains proceeds directly without intermediate disordering; this is referred to as the "cell" mechanism and it is associated with a progressive hardening of the initially annealed grains until the equilibrium of the second stage of the test is reached. At the higher rates, dissociation of the grains is accompanied by a structural disorder; the latter is then removed on continued deformation to reveal the fundamental substructure. This is a "two-stage recovery mechanism" and is associated with a progressive softening of the metal.

The primary creep curve is a resultant of these two mechanisms. In general, combination of cell formation and recovery appears to be as follows: At the beginning of deformation the grains start to dissociate into a substructure of average size rapidly approaching that typical of the ultimate secondary creep rate; this breakdown will lead to progressive strain hardening until the latter equilibrium is attained. Superimposed on this direct dissociation is a disordering of the structure (presumably at the subboundaries). At first, this adds to the hardness, but the effect is rapidly removed with continued deformation, and should cause some softening. Actual shape of the primary creep curve depends on the extent of this incidental softening in comparison with the more fundamental hardening associated with dissociation to the cell structure. During creep, grains form a substructure whether they are initially in annealed or disordered state.

(Continued on p. 412)

*Abstract of "Mechanism of Primary Creep in Metals", by W. A. Wood and R. F. Scrutton, *Journal, Institute of Metals*, Vol. 77, July 1950, p. 423.



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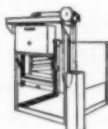
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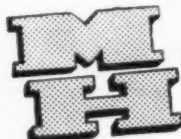
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Mechanism of Primary Creep

(Starts on p. 410)

The present results lend no support to the assumption sometimes made that creep reflects a running balance between strain hardening and recovery. On the contrary, they show that the disordering associated with marked strain hardening usually vanishes in the early stages of deformation. At slow creep rates the grains dissociate without any intermediate disordering. At high strain rates, the concept of "polygonization" might apply. (Stresses may bend the crystalline glide planes, but when the strained lattice breaks up into smaller units each with substantially flat glide planes the process has been termed "polygonization".) However, the preferred alternate view is that the substructure becomes evident as the finer crystallite debris is absorbed into the main fragments formed by deformation.

THOMAS G. DIGGES

Plated Aluminum*

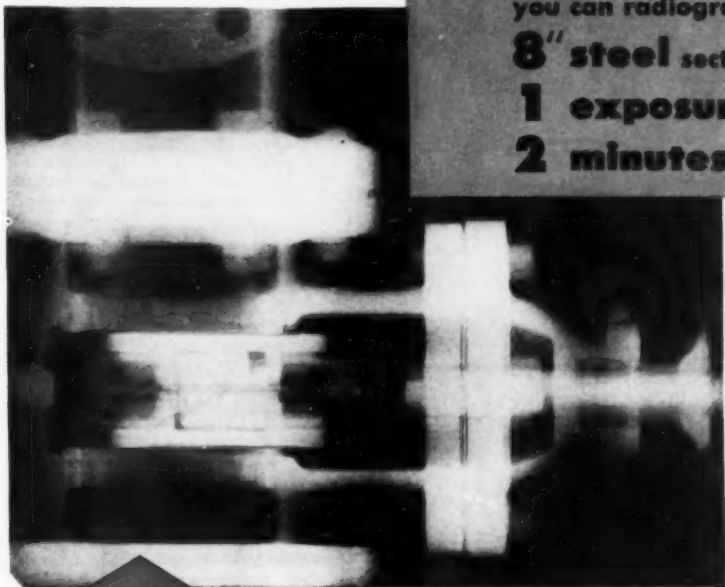
THE effects of chromium plating on duralumin were investigated in 1940 by A. Beerswald and in 1941 by H. Wiegand. In the work reviewed here, Raub investigated its effects on Hydronalium 7 (7.37% Mg) and Hydronalium 43 (3.43% Mg and 4.83% Zn). These wrought alloys were tested in alternating bending and in rotary bending. Raub apparently assumed the two to be identical, as his plotted data do not differentiate between the results.

The samples were pickled first in sodium hydroxide, then in acid ferric chloride, after which they were electroplated to a thickness of 0.002 to 0.012 in. They were tested as ground, as polished, as pickled, and as plated. For a few specimens, the plating was removed and the bare bars tested.

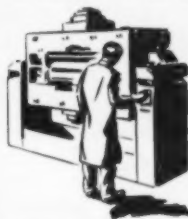
Grinding and polishing gave identical fatigue values. The fatigue curves for Hy 7 as pickled were parallel to the same in the polished condition, differing by approximately 2800 psi. (Cont. on p. 414)

*Abstract from "Influence of Hard Chromium Plating on the Fatigue Strength of Aluminum Alloys", by Ernst Raub, *Metallforschung*, Vol. 2, 1947, p. 121-126.

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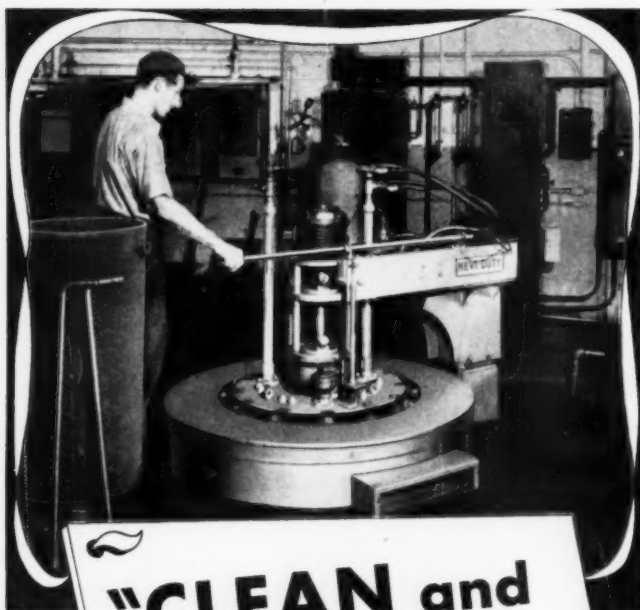
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Plated Aluminum

(Starts on p. 412) On chromium plating, the fatigue strength increased; apparently a smooth plate of about 0.008 in. thickness might give the alloy an increased life.

The alloy containing zinc (Hy 43) behaved quite differently. Pickling reduced its fatigue strength enormously and chromium plating did not bring it close to the fatigue values for the polished specimens. The plating readily developed warts and the fatigue curve for such samples dropped abruptly.

The experimental points are quite widely scattered on the S-N graph; therefore, the estimation of fatigue limits was rather uncertain. The author indicates the fatigue limits at 40 million cycles to be 21,000 psi. for Hy 7 and 28,000 psi. for Hy 43, and he states that the drop is about 600 psi. for each ten-fold increase in the number of cycles. This would mean that for the usual period of 500 million cycles adopted for aluminum alloys in the U. S. the limits might be 20,000 and 27,000 psi. — considerably higher than fatigue values reported for high-strength aluminum alloys in this country.

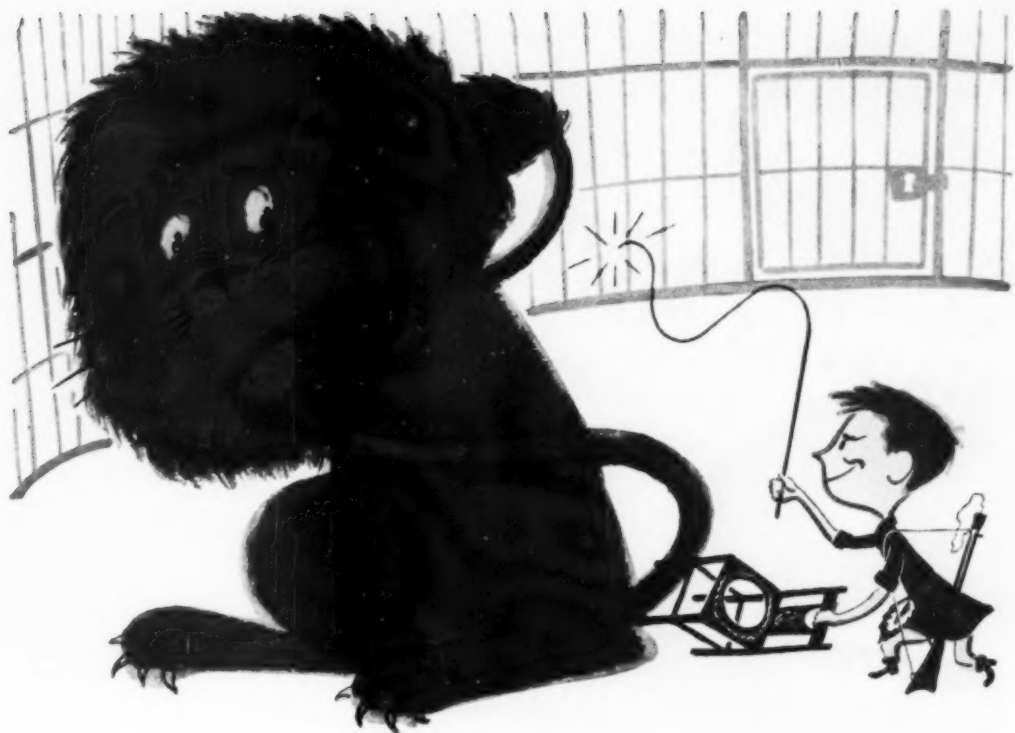
On the whole, Raub's research, like the previous work on duralumin, proves that chromium plating is likely to decrease the fatigue strength of aluminum alloys considerably. However, the decrease may be acceptable where the wear resistance of the chromium plate is of great importance.

M. G. CORSON

Cost of Corrosion*

ECONOMIC and material losses through corrosion of metals are divided into (a) the direct loss resulting from protection costs and replacement of corroded equipment and (b) an incalculable, often higher, indirect loss through shut-down, overdesign, loss of product and efficiency, explosion, and contamination. Direct loss by corrosion, although amenable to analysis, still is difficult to estimate. The author says that annual (Cont. on p. 416)

*Extracts from "The Cost of Corrosion to the U. S.," by Herbert H. Uhlig, *Chemical and Engineering News*, Vol. 27, Sept. 26, 1949, p. 2764-2767.



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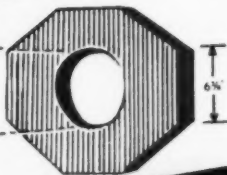
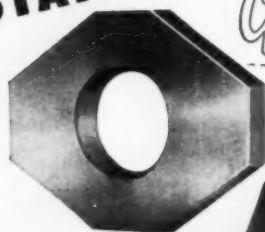
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Cost of Corrosion

(Starts on p. 414) cost to the United States amounts to over \$5,500 million. Previous estimates in the order of \$500 million to \$1,000 million are definitely too low.

The author's estimate of annual direct losses by corrosion are listed in Table I. The losses are calculated on the basis that all measures which apply to the protection of metals, or which increase the cost of materials over that of steel, should be included. Labor charges for application or replacement are considered part of the costs. The final cost figure of Table I, in any case, should be considered on the low side, since future, more exhaustive attempts to estimate true costs are likely to raise this total appreciably.

Indirect losses cannot be estimated and are not subject to even an educated guess. This is particularly true since they include loss of life and limb, and psychological factors attending unpredictable failure or explosion. Furthermore, losses of materials and of dollars and cents through corrosion of industrial equipment seldom become public information. Enough convincing examples are on record, however, to show that these losses reach a high order of magnitude. They include loss of oil, natural gas, and water through corroded pipes, reduced capacity of pipe lines, spoilage of food in metal containers, and shutdown of water supply, electric power, manufacturing plants, and transportation.

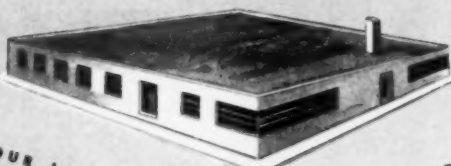
Large as are these more obvious indirect losses, there are also similar losses less readily recognized. For example, appreciable tonnages of metal are consumed needlessly each year because equipment is overdesigned to take care of corrosion. Because corrosion rates may be unknown, the design engineer often specifies several times the required thickness of metal to insure adequate strength and continued performance. Except for corrosion, the factor of safety might be much less. Overdesign is common in the construction of reaction vessels, boiler and condenser tubes, buried pipe lines, oil-well sucker rods, water tanks, and marine structures.

Proposed Research Program—Not all of the material loss can be prevented, but much can be accomplished through further engineering effort. (Continued on page 420)

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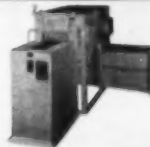
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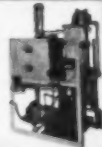
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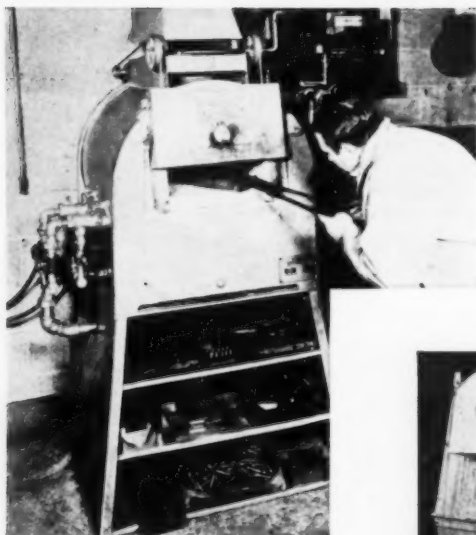
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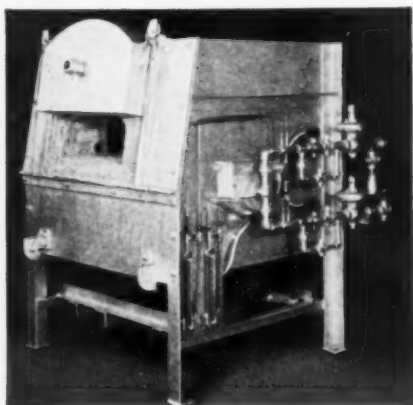
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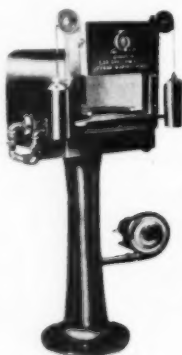
Most builders of heat-treating furnaces agree that somewhere in almost every furnace Super Refractories can be used to advantage.

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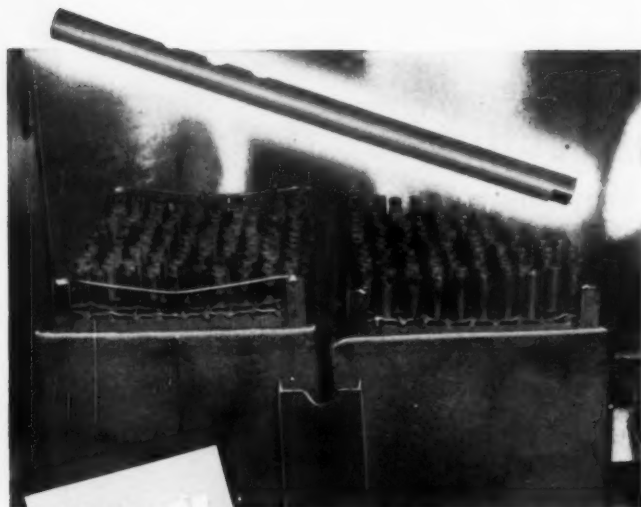
"Before we switched to Gulf Stainless Cutting Oil, staining of brass and aluminum parts was a problem in our shop," says this Machine Shop Foreman. "It became necessary to dip these parts in Stoddard Solvent to remove the corrosive cutting oil. With Gulf Stainless Cutting Oil we've been able to eliminate this operation—and we get no more staining. The result—lower costs, increased production!"

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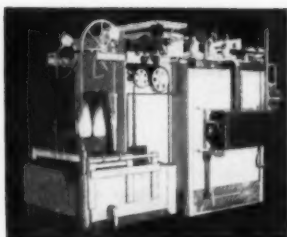




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Cost of Corrosion

(Continued from p. 416) Continual thoughtful planning for the future, based on established facts and past experience, is necessary to human survival. For this reason, a summary of predicted reasonable gains to be made by a well-directed research, development, and educational program over the next five years may serve some purpose. This is done in Table II. An investment of 0.5 to 1% of the amount to be saved would provide adequate support for such a program.

The savings, of course, are not alone in dollars and cents. There are direct and indirect savings of metals, coal, oil, water, and other exhaustible material resources.

Table I — Annual U. S. Direct Loss by Corrosion
(Including Costs of Corrosion Control)

1. Paints, varnishes, lacquers (50% of est. production)	\$ 585,000,000
Labor (250% of paint cost)	1,460,000,000
2. Phosphate coatings	20,000,000
3. Galvanized sheet, pipe, wire (2.5¢/lb. differential over black iron)	136,500,000
4. Tin andterne plate (4¢/lb. differential over black iron)	316,000,000
5. Cadmium electroplate	20,100,000
6. Nickel and nickel alloys	182,000,000
7. Copper and copper alloys (20¢/lb. differential)	50,000,000
8. Stainless steel	620,400,000
9. Boiler and other water conditioning	66,000,000
10. Underground pipe maintenance and replacement	600,000,000
11. Oil refinery maintenance	50,000,000
12. Domestic water heater replacements	225,000,000
13. Internal combustion engine corrosion	1,030,000,000
14. Automobile mufflers	66,000,000
TOTAL	\$5,427,000,000

Table II — Predicted Annual Savings
(By Five-Year Research, Development, and Educational Program on Corrosion Control)

1. Paints, varnishes, lacquers (10% improvement in life)	\$205,000,000
2. Galvanized sheet, pipe, wire (10% improvement in life)	13,700,000
3. Nickel electroplate (10% improvement in life)	1,200,000
4. Increased use of inhibitors and water conditioning	200,000,000
5. Buried and submerged structures	120,000,000
6. Domestic water heater replacements	55,000,000
7. Internal combustion engines	310,000,000
8. Automobile mufflers	17,000,000
TOTAL	\$821,900,000

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Detroit this fall. Leading metallurgists and industrialists in metal producing and metalworking plants in the Marshall Plan countries, as well as other friendly European nations and countries in South America and Central America, are being invited to attend and participate in the Detroit meeting. This activity has the approval and assistance of the Economic Cooperation Administration.

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Fatigue Strength of Cold Worked Aluminum*

COLD WORKED metal shows certain differences in tensile strength and ductility in different directions, but the variations rarely exceed a few per cent. The authors offer a combination of fatigue and micrographic studies capable of substantially increasing our knowledge of directional variations in cold worked metal. However, they limited their work to pure aluminum, annealed, medium hard rolled, and fully hard rolled.

The method consisted in running torsional fatigue tests on strips 0.039 in. thick and 0.394 in. wide at a maximum stress of 11,000 psi. for the medium hard rolled metal and 2600 psi. for annealed strips. The specimens were taken in five directions, 0, 22½, 45, 67½ and 90° to the direction of rolling. Ten sam-

ples from each orientation were run to failure. The results show that sensitivity to fatigue depends sharply on the direction of the fibers in the first 45° from the rolling direction, while beyond that the capacity to withstand fatigue is almost uniformly low—just a little greater than for the annealed metal. The types of fracture are also quite different but these differences vary through the whole range. At 90° to the direction of rolling the samples fail by a sharp parting of the fibers. In between, "staircase" fractures form.

Interesting also is their method of studying the structural changes during fatigue tests. A sample is electropolished, run for a definite number of cycles (9000 per min.), etched and examined; then it is run for another period, re-etched and examined again; and so on. The published micrographs do less than full justice to the author's work.

M. G. CONSON

*Abstract from "The Use of Fatigue Tests in the Investigation of Structural Characteristics of Cold Worked Metals", by R. Jacqueson and P. Laurent, *Revue de Metallurgie*, 1949, p. 89-101.

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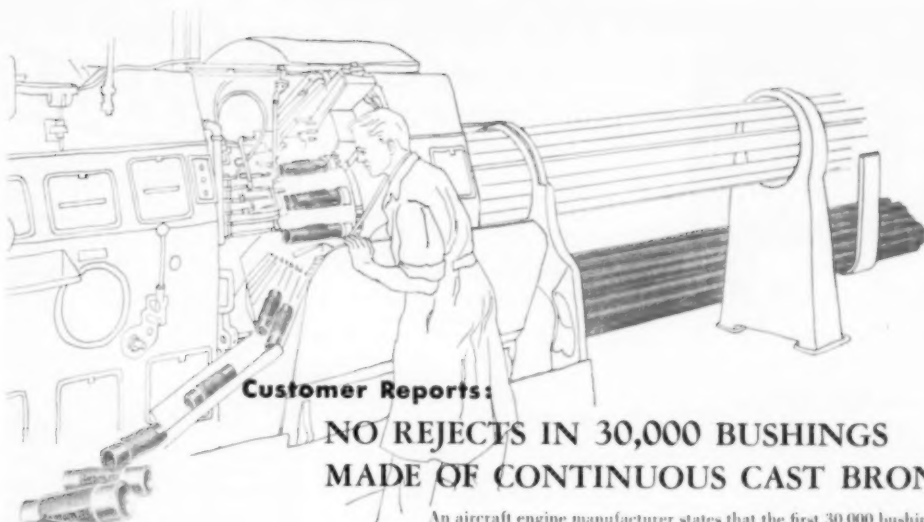
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Note in these photomicrographs the superior dispersion of constituents in the continuous cast alloy... also its outstanding freedom from metal faults.



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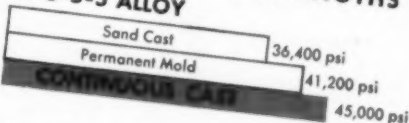
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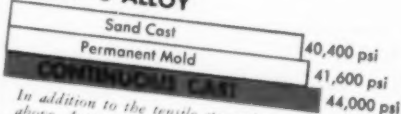
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X-Ray Studies of Creep in Aluminum*

AN ATTEMPT was made by Mr. Greenough and Mrs. Smith to apply the dislocation theory to the experimental observations of Wood and his associates on "cell" formation during plastic deformation and to those of Cahn on "polygonization". (See the abstract "Mechanism of Primary Creep" in this issue of *Metal Progress*, p. 410.) The validity of these concepts is tested by radiographs made both on high-purity and commercial aluminum specimens tested at slow and fast strain rates.

Creep of aluminum at slow rates and high temperatures is characterized by viscous flow. At a selected deformation the number of dislocations remaining in the lattice is less for slow strain rates and high temperatures than for high rates and low temperatures. The size of the cells thus will increase as the distance between the lines of dislocations is increased.

X-ray diffraction spots become more diffuse — a condition which is indicative of increase in the number of dislocations — as the strain rates are increased or the purity of the aluminum is decreased. The foreign atoms dissolved in the lattice or the precipitated particles in the low-purity metal can act as dislocation "traps"; due to the increased number of dislocations which are present in this condition, the susceptibility to formation of large "cells" is decreased.

Results of two-stage tests, for deformation at elevated temperatures subsequent to rapid extension at room temperature, are also presented in the paper under review. They showed that fragments formed during such a test routine are smaller than those produced from the strain-free state in which the complete tests were made at elevated temperature.

If one assumes that deformation of crystals in a polycrystalline material is inhomogeneous, it is possible to explain the results of Wood and collaborators by adopting the Cahn theory of polygonization.

THOMAS G. DIGGES

*Abstract of "The Mechanism of Creep as Revealed by X-Ray Methods", by G. B. Greenough and Edna M. Smith, *Journal, Institute of Metals*, Vol. 77, July 1950, p. 435.

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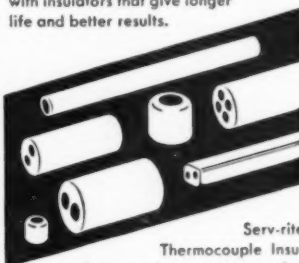
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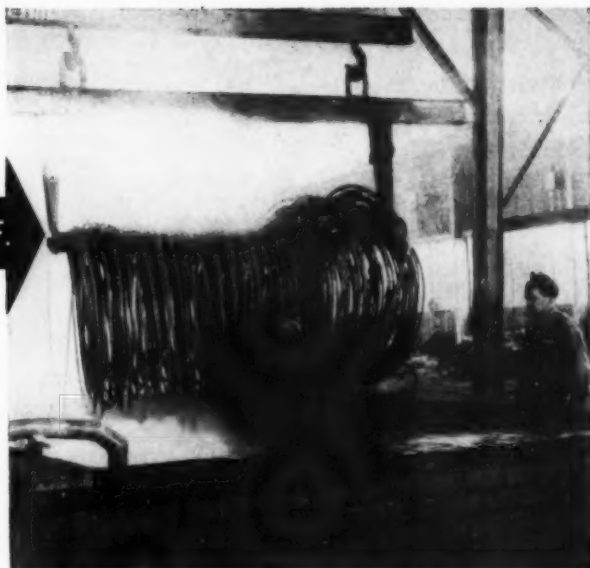
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This HASTELLOY alloy pickling assembly operates in a violently agitated, heated solution of sulphuric acid. The solution is oxidizing in nature at the liquid level, and strikes against the assembly at high velocities. In the face of these severe conditions, the corrosion rate of the assembly is only 0.002 to 0.007 in. per year.

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Here is the HASTELLOY alloy clad yoke bar and trunnion before assembly.



The I-section is joined to the hook with HASTELLOY alloy welding rod.

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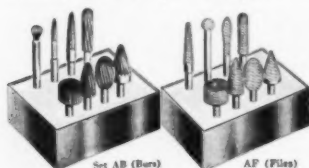
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Metal Progress; Page 426

German Light Metal Industry*

IN GENERAL, the greatest portion of virgin aluminum and magnesium was produced in Germany by well-known and established methods although some variations in techniques were noted. The Bayer purification process was used for the production of alumina from mono-hydrate bauxite.

Red mud utilization in Germany developed along two principal methods: (1) The production of soluble slags from a mixture of red mud, the more refractory bauxites, and clays by smelting in a blast furnace; and (2) use of steel scrap in place of the bulk of red mud. It was found that a slag consisting mainly of $\text{CaO} \cdot \text{Al}_2\text{O}_3$ yielded the best solubility. The process was considered economically sound in joint operation with a Bayer plant. The electrolytic reduction of

alumina conformed with conventionally known practices and no important changes were noted either in equipment or method. No notable developments were reported in equipment or methods of producing magnesium. The majority of the magnesium was produced by the electrolysis of magnesium chloride. There were no major developments in the electrolytic reduction process for magnesium. Larger cells were used, with 4 instead of 3 anodes; the anode to cathode spacing was reduced simultaneously from 16 to 12 cm., thereby diminishing both the cell voltage and power consumption.

Molten alloys from scrap melting processes were either cast into pigs or ingots, mixed with pure metal and cast into pig or ingot, or further refined. The two main production processes used for further refining were the magnesium (Beck process) and the three-layer electrolytic process. Efficiencies of up to 80% were reported in the recoveries of useful alloys from swarf or (Continued on p. 428)

*Abstracted from "The Non-Ferrous Metal Industry in Germany During the Period 1939-1945 (Light Metal Portion)", Report No. 23, obtainable from British Information Services, 30 Rockefeller Plaza, New York City 20. (90¢.)

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Bassick Co., Bridgeport, Conn., makers of casters and hardware, rely on Homocarb furnaces such as the one above for all cyaniding. Left: typical samples of Bassick production.

Bassick Co. cuts cyaniding costs 2/3 rds by switching to Homocarb heat treating

By installing three Homocarb furnaces to replace the salt pots formerly used, the Bassick Company has not only reduced cyaniding costs per pound to one third of the previous amount, but in addition, it is now getting 59% more heat-treating production from the same floor space. Big, efficient Homocarb furnaces handle over 100 tons a month production of hardened small casters and hardware parts with ease . . . eliminating the need for sending a portion of the work to outside heat treaters.

In addition to these benefits, the company finds that the quality of case is much more closely controlled with the Homocarb method. Case averages about 5 thousandths deep; is uniformly hard. Spot checks of hardness are made by file and by Rockwell.

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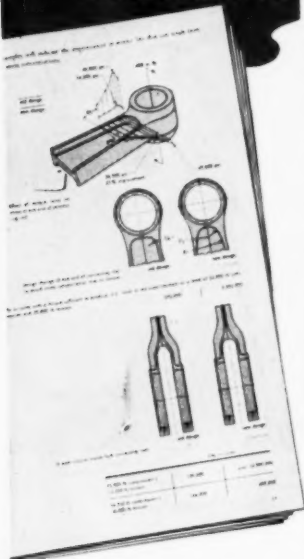
Here are some benefits...

- **Fewer rejects** . . . because process is always under full control and uses uniform, standardized gas cyaniding medium, evenly heated and distributed. Heat treater doesn't have to guess at furnace conditions . . . he knows them.
- **Uniform production** . . . because method's controllability means results can be duplicated time and time again.
- **Faster production** . . . furnace fits into production lines without affecting use of adjacent equipment. In addition, furnace can be reloaded with practically no waiting between batches.
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German Light Metal Industry

(Begins on p. 426)

dross. Metal recovery with large scrap in sloping hearth furnaces varied between 50 and 75%.

Low frequency induction melting furnaces of 3 to 4-ton molten metal capacity with either vertical or horizontal channels were the most popular although reverberatory, roof, electric and lip axis tilting furnaces of various types and designs were used for melting and holding molten aluminum alloys. It was reported that life of the induction furnaces was extended by coating the lining with 10% cryolite and 90% sodium chloride flux which was maintained in a molten state for 5 to 6 hours. Conventional steel crucible-type furnaces were reported to have been used for melting magnesium alloys.

Because of the extensive use of electric melting, fluxing and degassing of aluminum alloys were seldom required. However, a flux consisting of 95% sodium chloride and 5% cryolite was the one most widely used in scrap melting practice. Grain refining of magnesium alloys was accomplished by adding iron chloride (Elfinal process) to the molten bath.

Other than aluminum-silicon alloys, most hardeners were produced by melting a mixture of the pure metals. Aluminum-silicon temper alloys were made on a wide scale by the direct reduction of clay and alumina in either a single or three-phase furnace. The alloys produced were refined further in a modified reduction furnace at a temperature of 2552° F. with a flux to remove calcium and magnesium.

Magnesium alloys were cast in great quantities by the "water-sinking" process, a modification of the standard water-cooled mold process. Thin steel cylinders were preheated to 572° F. and filled with molten alloy in the "water-sinking" process. The cylinders were covered with an electrically heated lid, held 40 to 60 min., and then lowered into water by means of a movable platform at an approximate speed of 1 in. per min. for a 15-in. diameter billet. It was claimed that the water-sinking produced a better surface and superior quality of final products for ingot sizes larger than 12 in. in diameter as compared with semicontinuous methods of casting. (Continued on p. 430)

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German Light Metal Industry

(Continued from p. 428)

The more important develop-
ments in light alloy founding were
the development of rubber-lined
patterns and the use of synthetic
core binders. The main advantages
of the rubber-lined patterns over
conventional types were 8 to 10
times longer life and better repro-
ducibility. A shortage of standard
core binding materials prompted
the development of synthetic sub-
stitutes. A typical material was
called "Alkylin", a cellulose deriva-
tive. Some of the benefits reported
with the synthetic materials were
shorter baking times, lower baking
temperatures, less volatile matter
released during casting and easy
collapsibility.

Two Mahle die-casting (hot
chamber) machines were devel-
oped: (1) A "hot air injection"
type operating at an air pressure of
450 to 700 psi. and producing 10
to 40 castings per hour, ranging in
weight between 1 and 15 lb.; (2) a
"hydraulic plunger" type operating
at 1500 psi. applicable to small cast-
ings (2 lb. or less) and producing
100 to 400 castings per hour. Water-
cooled dies were operated at
482 to 572°F. and were not lubri-
cated. These machines produced
magnesium castings 30% cheaper
than aluminum castings by the cold
chamber process. Centrifugal cast-
ings of light alloys were introduced
experimentally but the process was
not used in production.

Magnesium alloys were rolled on
standard rolling equipment using
high pressures and slow speeds.
Flattening on a sheet mill was pre-
ferred to roller levelling for the pro-
duction of high quality sheet. In
cladding magnesium foil either tin,
cadmium or zinc (0.01 mm. thick)
was inserted between the basic ingot
and the cladding material.

The conventional Schloemann
extrusion press was used extensively.
Approximately 25% greater output
was attained utilizing water-cooled
dies, although the use of these dies
increased die breakage. Products of
higher quality and increased die life
were obtained by using chromium
plated dies. Better mechanical prop-
erties and higher corrosion resist-
ance of products were attained by
spray-quenching the extrusions as
they left the die. This technique
was used with many aluminum-base
alloys but not with magnesium
alloys. Conventional straightening
and age-hardening followed.

Unlike aluminum alloys, magne-
sium-base alloys were not spray-
quenched during the extrusion
process. The output of a press was
increased 5 times by using water-
cooled dies and dummy blocks and
preheating the billets to develop a
temperature gradient throughout the
length of the billet with the hotter
end next to the die.

The two cladding processes devel-
oped for coating steel with alumi-
num were: Heating steel articles in
sealed boxes containing refractory
powders carrying 20% fine alumi-
num turnings; and, utilizing alumi-
num chloride vapors. Protection
of magnesium-base alloys was gen-
erally accomplished by means of the
chromate process. Process was im-
proved by (1) pretreating the article
in caustic soda solution, (2) adding
phosphoric and sulphuric acids to
the bath, (3) adding chrome alum.

Corrosion resistance of the alumi-
num-magnesium alloys was im-
proved by (1) annealing at 842°F.
for 5 hr., followed by furnace cool-
ing to 212°F. at the rate of 212°F.
per 2 hr.; (2) annealing at 932°F.,
quenching in water at 194°F. fol-
lowed by aging at 392°F. for 8 hr.;
(3) cold reduction of 20 to 30% fol-
lowed by a short anneal at 572°F.,
air cooling and more cold work. A
lamellar structure in silumin which
induced pronounced ductility was
developed by (1) small additions of
arsenic or phosphorus and (2)
filtering.

Bearings were produced by cast-
ing, forging, extrusion and rolling.
Composite bearings were produced
by cladding an iron strip with alu-
minum foil by rolling at 932°F. fol-
lowed by cladding with a strip of
bearing alloy. Bearing alloys used
were: Duralumin plus 1 to 2% Pb;
aluminum plus 5% Zn with or with-
out minor additions of Si, Fe, Mg,
or Pb; and, an alloy containing 3%
Pb, 3% Sb and 3% Mn.

Main development in cable manu-
facture was a 99.99% aluminum
sheathing made in a vertical extru-
sion press. The insulating material
(polyvinyl chloride) was extruded
around the cable. The problem of
joining the lengths of cable was not
solved. Other developments in cable
manufacture were: wide application
of "Buna" synthetic polymers for
dielectrics; steel sheathing coated
with aluminum or zinc to replace
lead; and, employment of wood pulp
instead of cotton.

J. B. ENGLISH

Powder-Cutting

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Riser cutting of centrifugally-cast stainless steel rings used to be a difficult and time-consuming job. In one foundry which used a boring machine, this operation took eight hours per casting. When powder-cutting was introduced, the time was reduced to approximately 15 minutes—a 32-fold increase in production.

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Here, risers on stainless steel castings are being powder-cut—a time saving of 30 per cent over the former methods.

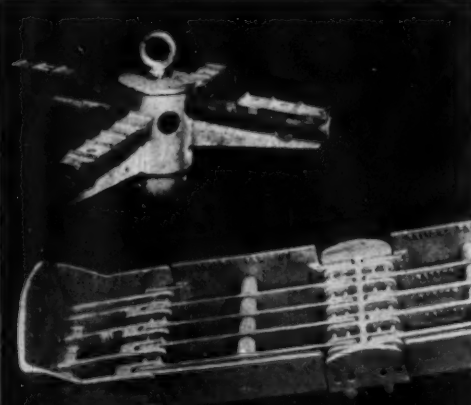
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Metal Progress; Page 432

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As a forging is merely "a casting with the hell slapped out of it"—so one may regard the "yard goods" of the same specie. Because a casting is a TRI-LAMINAR structure (the outside surfaces cool and solidify first, and are normally placed in compression by the later cooling and contraction of the "core"),—it resembles a carburized piece with a "case" and a "core", like tri-laminar plywood—and stiffer.

It is axiomatic that the stronger and stiffer (short of brittleness in use) an alloy is at high temperatures, the more it will resist deformation by rolling, or otherwise, and the higher the temperature and power required to roll it. Because of this the commercial rolled alloys are, in general, *metallurgical compromises*, lower in carbon and other alloying ingredients to facilitate their deformation by rolling. (The stronger alloys edge-crack as the edges cool down in rolling, require trimming, reheating, etc.)

General Alloys pioneered in introducing rolled alloys—importing them from England rolled to our specifications in 1920. We installed sheet alloy camshaft carburizing tubes in Buick in 1921—and supplied thousands of sheet fabricated boxes and muffles years before most of their present sponsors were aware of their existence.

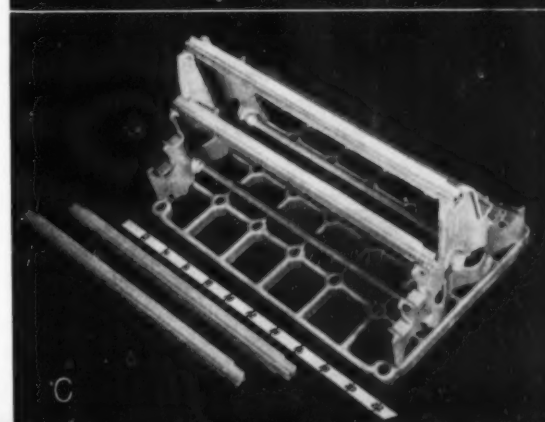
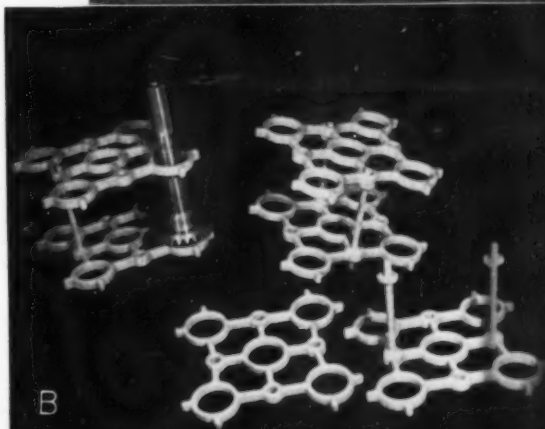
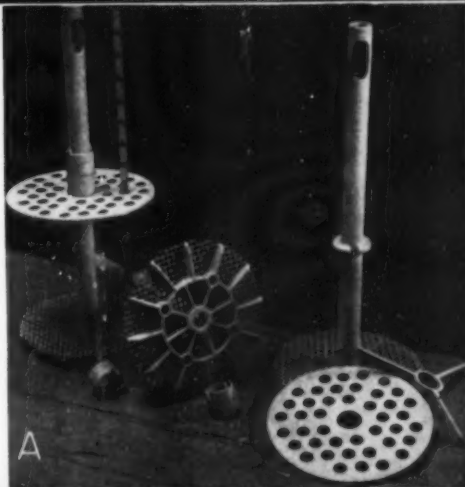
"Thin" stuff is an appealing idea. Under certain conditions of light loads, as where it functions primarily as a "can" of very simple form or as a liner *weighted against warpage*, it has some economic justification—but such cases, *factually analyzed*, are few and far between.

Anyone familiar with the pack carburizing process, and with the fact that combustion of the compound adds to radiation transfer, knows that there is no measurable time saving between a $\frac{1}{4}$ " cast box and the thinnest usable sheet or cast box. As the oldest fabricator of sheet and cast alloys and holders of various patents on same, we have always sought to employ sheet or mill products singly or in engineered integration with castings where they are economically indicated. Pattern costs in some cases favor fabricating fixtures in very small quantities from bars. Often there is a minimum of load or stretch, and ample support from stiff, shape-holding cast grids can be provided. G.A. employs wire screens (as shown in photo A).

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Ed. C. Carver

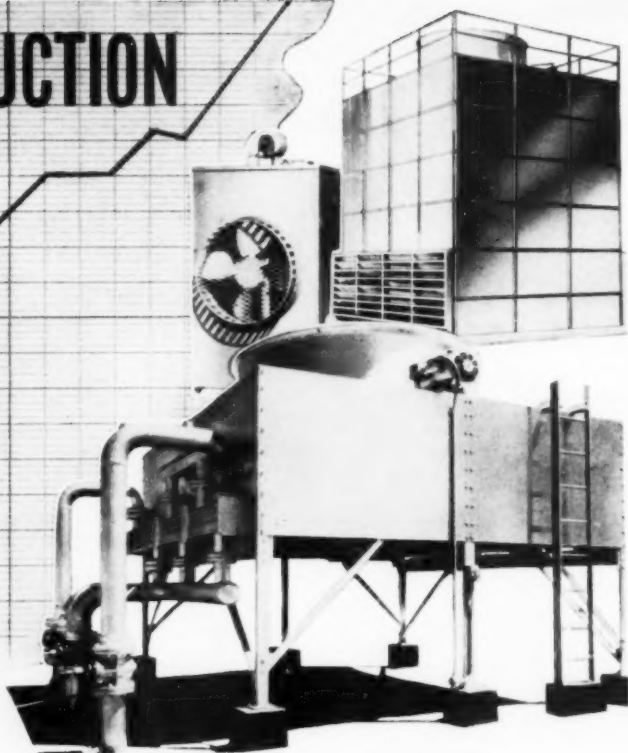
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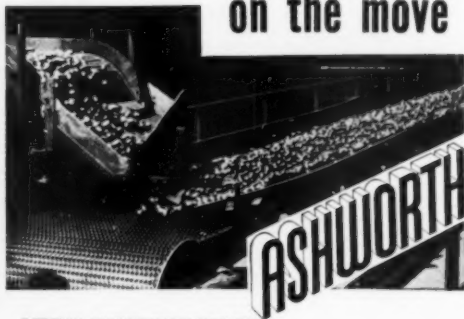
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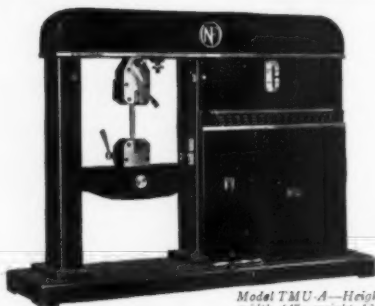
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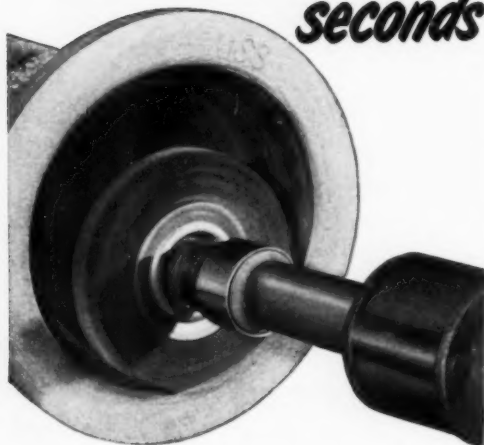
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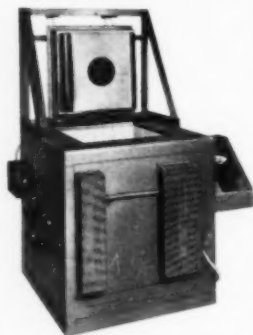
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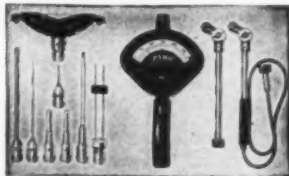
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ASTM	American Soc. for Testing Materials	B86-XXI	B86-XXIII	B86-XXV
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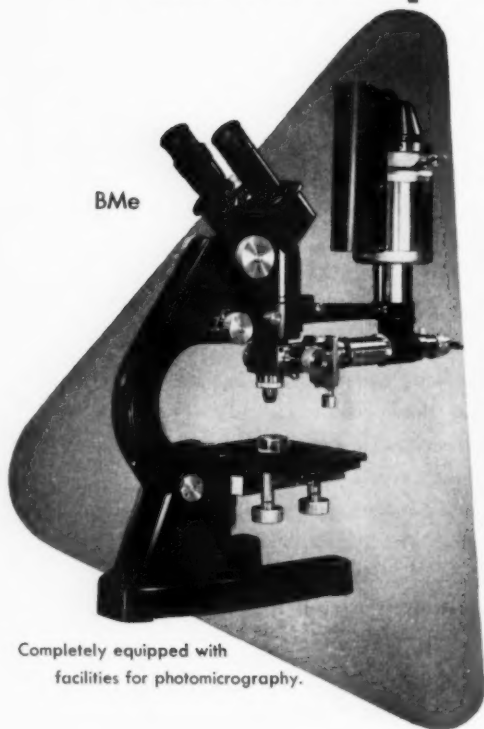
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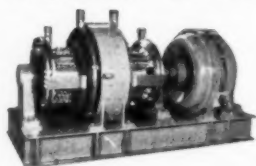
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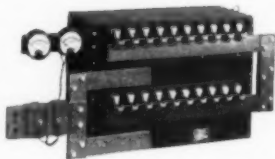


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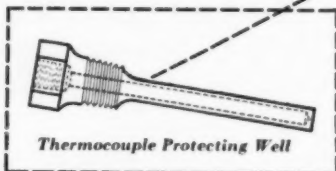
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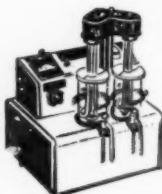
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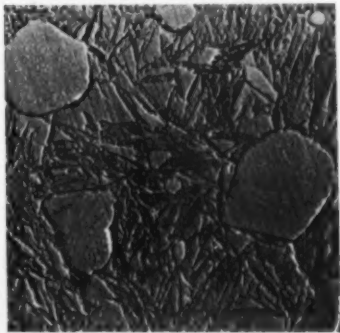
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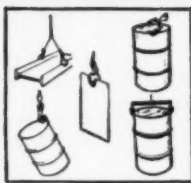
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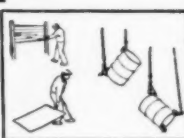
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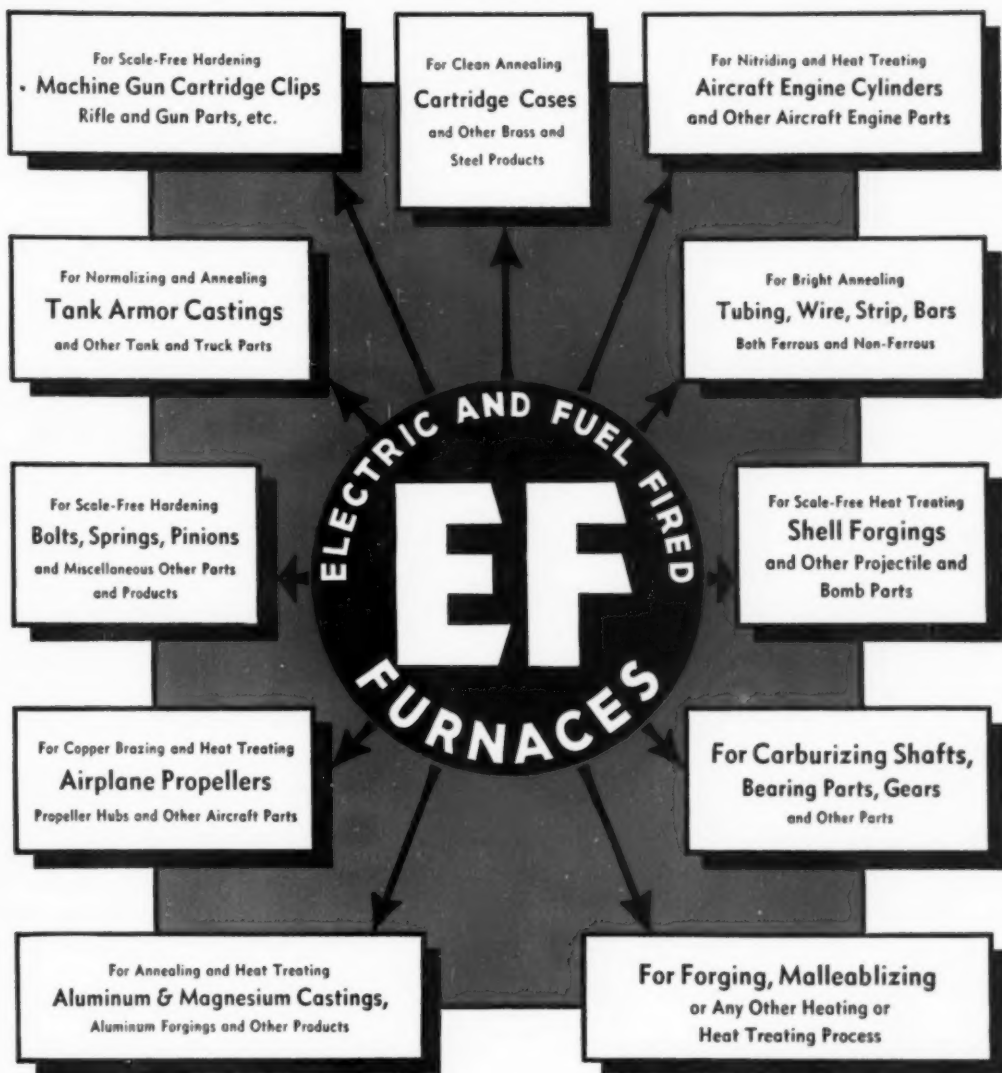
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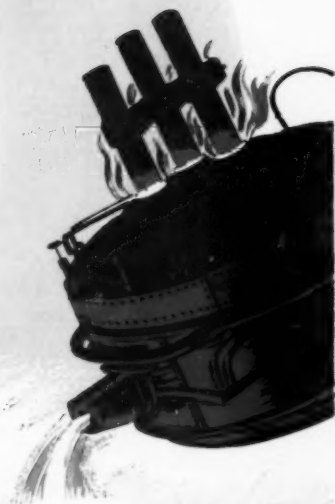
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